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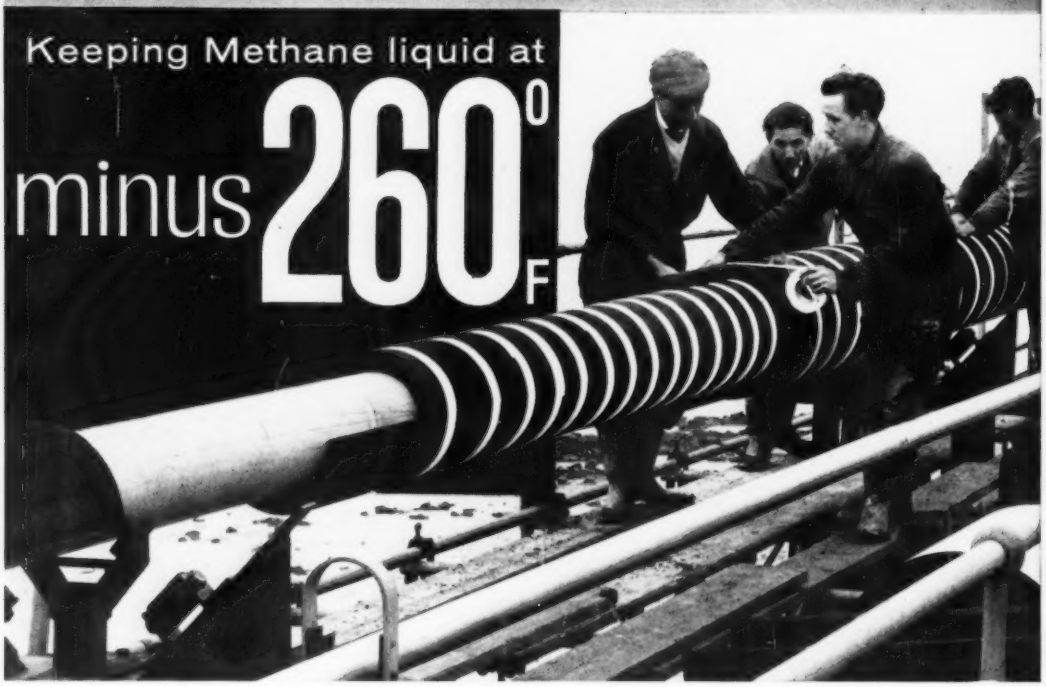

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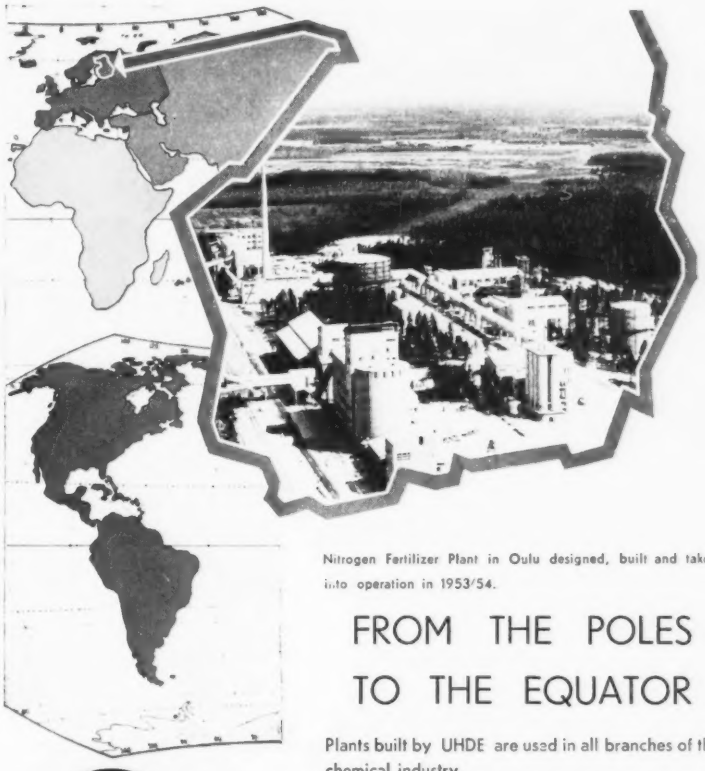

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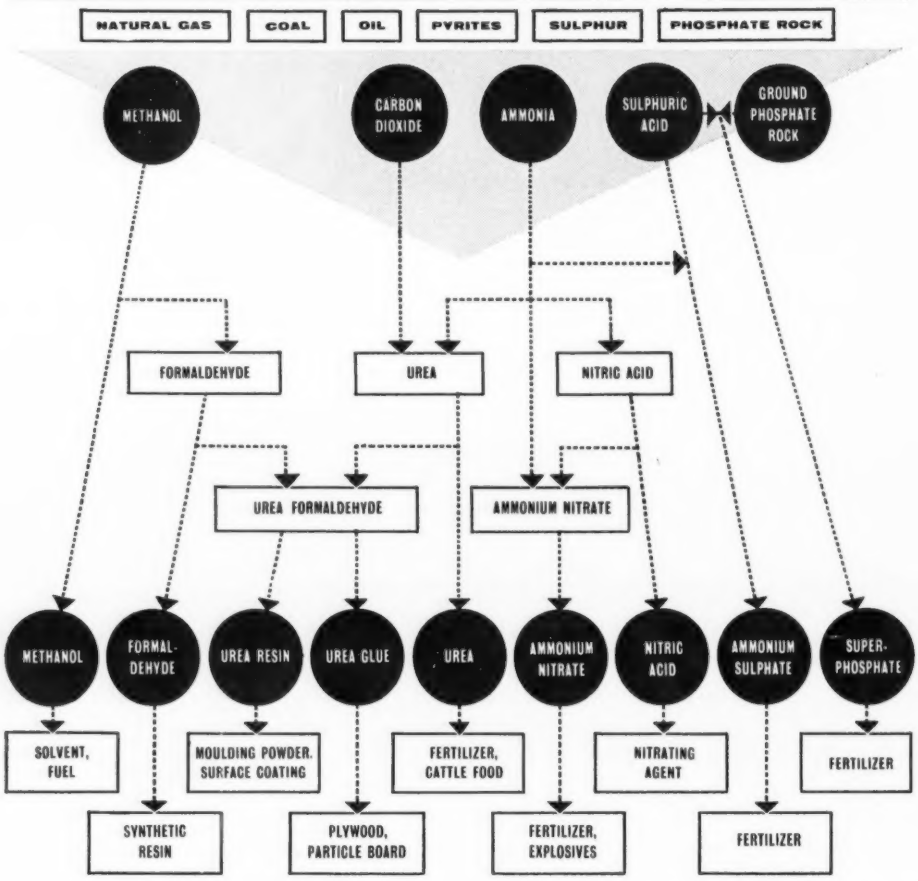

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THE NEAR EAST

THE MAJORITY of large scale producers of nitrogen throughout the world look to export markets for an outlet for a substantial proportion of their production. Versatility of operation and increasing efficiency intensifies their determination not only to maintain but to expand overseas markets. At the same time the underdeveloped countries of the world are anxious to achieve a high degree of self-sufficiency in fertilizer nitrogen. The Near East is among six major areas in the world which offer exceptional prospects for the expansion of fertilizer nitrogen use.

If the volume of fertilizer use in the Near East is to be appreciably expanded or even maintained, far reaching measures will be needed to stimulate the agricultural development of this area. Exports to the countries under review, now at an annual level of 200,000 tonnes N, have risen by 60% since 1954/55. Imported nitrogen accounts for four-fifths of all supplies, but the future growth of these markets would be in the face of a substantial projected increase in domestic production. Plant construction already in progress or planned is to raise the nitrogen capacity of the Near East to 304,000 tonnes N by 1965.

Consumption

Although it has risen by 63% in the last five years, consumption of fertilizer nitrogen in the Near East, at its current annual level of 247,000 tonnes N, represents only 2½% of the world total. With Egypt and Israel alone accounting for 204,000 tonnes N, the remainder of the area, with a population of 57 million, has an annual consumption level of only 825 tonnes N for every million people.

Fertilizer Nitrogen Consumption 1958/59
000 tonnes N per 1 million inhabitants

Egypt	7.6	Netherlands	17.9
Israel	7.0	U.S.A.	14.0
Lebanon	4.0	France	11.8
Sudan	1.4	West Germany	11.6
Syria	1.0	Japan	7.2
Turkey	.7	Spain	7.2
Jordan	.2	United Kingdom	6.6
Iraq	.1	Canada	2.1

A common symptom of all underdeveloped countries is that the growth of population is outstripping the rise in gross national product and food supply, thereby preventing a rise in the standard of living. Agricultural output per capita in the Near East is lower than before World War II and if it is to support a population increasing at a rate of 2% a year at even the present standard of living, the present trend must be sharply reversed.

Agriculture

An excessive reliance on the fluctuating productivity of rain-fed land or on uncontrolled seasonal flooding is a characteristic of agriculture in nearly every country of the Near East. In Iraq, for example, in years when there are low floods on the Tigris and Euphrates the rice crop has been cut by 50%. Permanent irrigation is not only inadequate but is in many cases inefficiently operated and often damages the fertility of the soil. The area under cultivation is expanding at an average rate of 2.7% per annum but rain-fed land is being brought under the plough at a faster rate than irrigated land. Of the 45 million hectares at present under cultivation, only 4½ million hectares are under permanent irrigation. The continued

Traditional methods of farming, unchanged for centuries.

spread of the cultivated area is accompanied by increasing erosion and a decline in the fertility of the land.

Another characteristic of agriculture in the Near East is small scale production and high costs of marketing and distribution, all contributing towards low incomes for farmers and a lack of incentive for them to invest in improvement and expanding output. There are, of course, some notable exceptions to this prevailing rule of agricultural stagnation and the problems and potential development of the whole area can be better understood by an examination of the conditions in each country.

Egypt

Dominating the nitrogen fertilizer picture in the Near East, the Egyptian region of the United Arab Republic accounts for 70% of the total production and 80% of the total consumption of the area. The first country in the Near East to establish a domestic nitrogen industry, Egypt nevertheless remains one of the principal importing markets in the world. Of her current annual consumption, over 80% is in the form of imports which have risen from 90,000 tonnes N in 1954/55 to the current level of 160,000 tonnes N. Principal supplies in 1958 originated as follows:

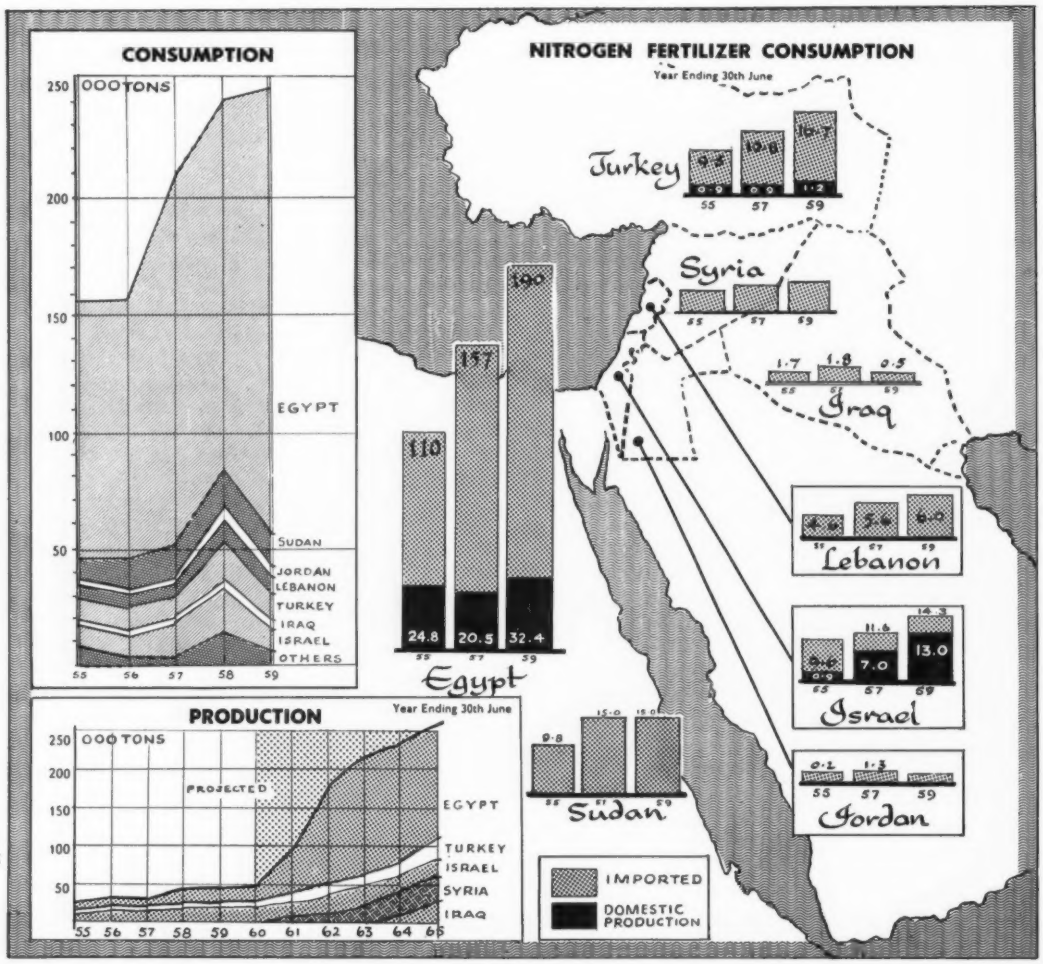


Fig. 1.

Exporter		000 tonnes N
Belgium	ammonium nitrate	36.2
Italy	ammonium nitrate	15.6
Netherlands	ammonium nitrate	3.6
West Germany ...	lime ammonium nitrate	25.3
East Germany ...	ammonium sulphate	23.8

The high level of fertilizer nitrogen consumption in Egypt has followed the agricultural development of the richly fertile lands of the Nile Valley and Delta. Running through Egypt on the last 960 miles of its course the Nile floods from July to October irrigating the summer crops of cotton, rice, sugar cane and maize, and leaves a fertile soil to support the winter crops of cereals, clover and in Upper Egypt, beans, lentils and onions. The completion of the Assuan High Dam, designed to double the area of arable land in Egypt, is likely to be a further stimulus to the rise in fertilizer nitrogen consumption — a rise which must continue if the population of 25 million is to improve its standard of living in step with its anticipated growth to 38 millions by 1975.

Imports will, however, have to face increasing competition from expanding domestic production. The Suez works of the Société d'Engrais et d'Industries Chimiques, the first nitrogen plant to be commissioned in the Near East, has an annual capacity of 40,000 tonnes N in the form of calcium nitrate. This capacity is now being raised 50,000 tonnes N while an additional increase of 20,000 tonnes N in the form of ammonium sulphate is contemplated. A second and appreciably larger plant is under construction at Assuan. This plant, due to come into operation in 1960 is being built by a Franco-German consortium for the Société Egyptienne des Produits Chimiques. Intially the capacity will be 80,000 tonnes N in the form of lime ammonium nitrate but this is to be raised to 120,000 tonnes N by 1961. By 1963 Egypt should have a domestic nitrogen capacity of 190,000 tonnes N, which although equivalent to her present annual consumption is unlikely to be adequate to meet the requirements of the newly irrigated lands.

Iraq

Of the countries under review, Iraq alone disposes of large regular investment funds, thanks to her oil revenues. Nevertheless the investment which has so far taken place has not been reflected in a higher standard of agricultural efficiency.

The use of fertilizer nitrogen, which has never exceeded 1,900 tonnes N, has declined to its present level of 500 tonnes N a year. This is largely the result of political upheavals arresting the country's agricultural development. There is potentially considerable scope for increased consumption but this will only be fulfilled if capital is made available for the expansion of the irrigated area and if there is an appreciable improvement in irrigation technique.

Iraq possesses an abundance of water and cultivable land, work has already started on a number of important irrigation projects and the problem of flood control has been virtually overcome. Of the 6.5 million hectares of arable land, 1.5 million are under irrigation. The Food and Agriculture Organization of the United Nations have estimated that this irrigated area can be doubled by 1975 and that agricultural output can be raised to five times its present level.

Iraq. Irrigation of crops.

On the other hand, there are as yet insufficient distribution facilities for the water already under control and much of the irrigated land lacks adequate drainage. Already, between 20 and 30% of the irrigated land is out of production as a result of salination caused by inadequate drainage and the fertility of the remaining 70% is seriously threatened. This situation can only be remedied and the present

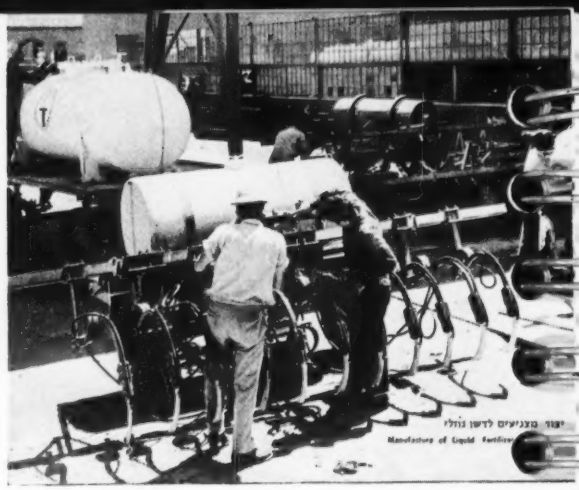
decline reversed by well directed investment and a drastic improvement in agricultural technique. This seems to have been very highly developed in ancient times, indicating that drainage facilities, roads and windbreaks must be built with the minimum delay and that in the long term an afforestation scheme would be well rewarded. The recent land reform law has removed many obstacles in the path of agrarian improvement but it must be fully implemented and coupled with an effective service of education in agriculture and fertilizer technique if any progress is to be made.

Israel

Enjoying a higher standard of living than any other country in the Near East, Israel has a per capita income of U.S. $500 compared with U.S. $180 in Turkey. The development of both agriculture and industry is proceeding at such a pace that it is expected that the per capita income will rise to U.S. $820 by 1975, whereas that of Turkey is only expected to reach U.S. $375 in the same period. While Israel received the lion's share of foreign aid to the Near East, her standard of living is in no small measure due to the efficiency of her agriculture. This has been stimulated by a relatively high level of investment which must be continued if the population is to maintain its present standard of living in step with its rapid increase. Now 2 million, the population of Israel is expected to double by 1975.

Not more than 100,000 hectares remain to be profitably brought under the plough, but of the 410,000 hectares already cultivated 130,000 are irrigated. The Food and Agriculture Organization of the United Nations have estimated that this area can be increased to 240,000 hectares by 1975. The scope for irrigation by gravity is limited, particularly in the Negev where the greatest potential for agricultural expansion exists and where attention is focused on the use of artesian wells.

The extension of irrigation and the further intensification of agriculture would bring with it a continued growth in nitrogen fertilizer consumption. Now at a level of 14,300 tonnes N a year, consumption has risen by 50% since 1954/55. Prior to 1955/56 the greater part of Israel's requirements were supplied from West Germany and Italy in the form of ammonium sulphate and lime ammonium nitrate but since



Israel. An assembly shop at the plant of Fertilizers & Chemicals Ltd., Haifa, for the manufacture of fertilizer applicators. The machines inject liquid fertilizers into the ground.

the opening of the Haifa works of Fertilizers and Chemicals Ltd. the volume of imports has fallen sharply in the face of growing domestic production. The capacity of the Haifa works, at present 10,000 tonnes N per annum, is to be doubled in 1960 and it is planned to raise it thereafter to 26,000 tonnes a year. Production has to date been largely in the form of ammonium sulphate but in future a greater part will be in the form of ammonium nitrate.

Fertilizer nitrogen is also to be produced by a second firm, Mayer Chemical Industries Ltd. which has recently commissioned a £1½ million carbide plant at Petah-Tikvah. Initially most of the carbide produced at this plant will be used in the manufacture of acetylene, but eventually it will also be used to make calcium cyanamide fertilizer.

Consumption, Production and Imports (000 tonnes N)

	54/55	55/56	56/57	57/58	58/59
Consumption ...	9.6	12.0	11.6	14.0	14.3
Production ...	.9	1.7	7.0	10.0	13.0
Imports ...	8.7	10.3	4.6	4.0	1.3

Although the availability of high analysis materials at increasingly competitive prices may maintain a foothold for foreign supplies of fertilizer nitrogen in Israel, the volume of imports is unlikely to regain its former level before 1975 unless there is some unforeseen change in the policy of national self sufficiency.

Jordan

In Jordan, although nearly 40% of the national income is derived from agriculture, consumption of nitrogen fertilizer does not exceed 300 tonnes N a year and its potential

growth is limited by the capital available for irrigation and education in improved agricultural technique. Jordan already receives a higher level of foreign aid per capita than any other country in the Near East, with the exception of Israel, and it is likely that funds will be made available substantially to improve agricultural output and maintain the present standard of living of the population. Now 1½ million, the population is expected to rise to 2½ million by 1975.

Of the 900,000 hectares of arable land, about 500,000 hectares are planted with wheat and barley, the remainder being left fallow. This cultivated area can only be extended by protective afforestation and by irrigation. The productive area at present does not extend beyond the East Jordan valley and the mountainous land behind it. West Jordan is fertile but severely eroded and it is here that the greatest scope for agricultural development lies. The remainder of the country is desert scrubland and could only be converted to productive land at great cost.

Lebanon

In the Lebanon there is a far greater scarcity of cultivated land than in Syria. The availability is only 0.2 hectares per head, one-sixth that of Syria, with a population growing at a rate of at least 2.5% a year. Unlike other countries in the Near East, however, the Lebanon depends less on agriculture for its national income than on the export of invisible services. This is a major weakness in economy, for if other countries fulfil their promise of becoming increasingly self-sufficient in respect of services, her ability to finance her imports will decline. There is, moreover, no official long term policy to develop and diversify the country's economy. Virtually all the progress made in both the commercial and agricultural fields has been due to the efforts of private enterprise. The economic strength of the Lebanon will largely depend on agricultural expansion which in turn depends directly on the availability of capital for extending the irrigated area. The ability of domestic private enterprise in this field seems to have reached saturation point and finance will be required from other sources if the potential increases in irrigation, and with it fertilizer application, are to be realised before 1970.

Consumption of fertilizer nitrogen in the Lebanon is now at an annual level of 6,000 tonnes N and has risen at an average rate of 7% a year since 1954. All supplies are imported and originate largely from West Germany and Italy. The intensity of application at 75kg. per hectare and eight times more than that in Egypt is already comparatively high and further increases in consumption will be closely related to the expansion of the irrigated area. Three-quarters of all fertilizer nitrogen used is applied to irrigated land. A number of irrigation schemes, including the Litani, Nahr El Assi, Ostuene and Nahr El Bared projects have already been initiated, but if these are to reach their potential development, additional capital and technical assistance will be required.

It is likely that much of the irrigated land will be used in the production of fruit and vegetables. Rapid progress has already been made in this field. The citrus crop which totalled 70,000 tons in 1944, rose to 123,000 tons in 1958, while the apple crop has doubled in five years. A continuation of this trend would point to the increased use of urea as a fertilizer.

Some two-thirds of the Lebanon cannot be used for agricultural purposes and the afforestation of much of this land would be an additional stimulus to nitrogen consumption. Imports of timber into the Lebanon now amount to L£20 million a year, but it is estimated that with the expenditure of L£120 million over 200,000 hectares could be added to the present forest area of 75,000 hectares and that production could be raised to one-half million cubic metres a year.

Sudan

The growth of cotton production in the Sudan has led to a progressive increase in the use of fertilizer nitrogen, particularly in the form of urea which accounts for over half of the current annual consumption of 15,000 tonnes N. There are as yet no plans for indigenous fertilizer production and all nitrogen supplies are imported, originating principally from Italy and the Netherlands. The Sudan will benefit from the increased irrigation facilities to be made available by the Assuan High Dam, agreement on which has just been reached. The Sudan will receive 14.5 million of the net 22 million cubic metres of water a year to be saved

Sudan. A regulator to control the waters from a main canal.

by the construction of the dam, thereby raising her total supplies to 18.5 million cubic metres. Possibly of greater importance is the Sudanese Government's ability to initiate discussions with the World Bank for the loan to build the Roseires Dam on the Blue Nile, which would provide irrigation for new lands capable of growing a greater variety of crops. A number of irrigation schemes are already in operation and one, the Gezira scheme, supplied from the Sennar Dam on the Blue Nile, accounts for the greater part of the cotton crop, the country's principal product. Great millet, sesame and ground nuts are other crops which play an important part in the Sudanese economy and which are also likely to expand with the extension of irrigation.

Syria

The situation in Syria is less urgent, although again the agricultural potential of the country will only be realised by far-reaching measures to extend the irrigated area, coupled with a substantial rise in fertilizer consumption. World War II was a strong stimulus to increased food production and today agricultural output still accounts for one-half the national income. Very little rain-fed land remains to be profitably exploited but until 1956, expenditure on irrigation was insignificant and of 4.9 million hectares under cultivation, only 500,000 are irrigated.

Consumption of nitrogen fertilizers, 4,200 tonnes N in 1958/59, has risen by 1,000 tonnes N in the last five years. The bulk of supplies, all of which are imported, originate from West Germany and are in the form of lime ammonium nitrate. The average yield per hectare of wheat and barley, two of Syria's principal crops, is as low as 600kg. per hectare, compared with 2,000kg. per hectare in Egypt and is evidence of the need for the increased application of fertilizer nitrogen. This can rise not only in step with increased irrigation but with greatly improved transport facilities, for both roads and railways in Syria are totally inadequate for an expansion of her agricultural economy.

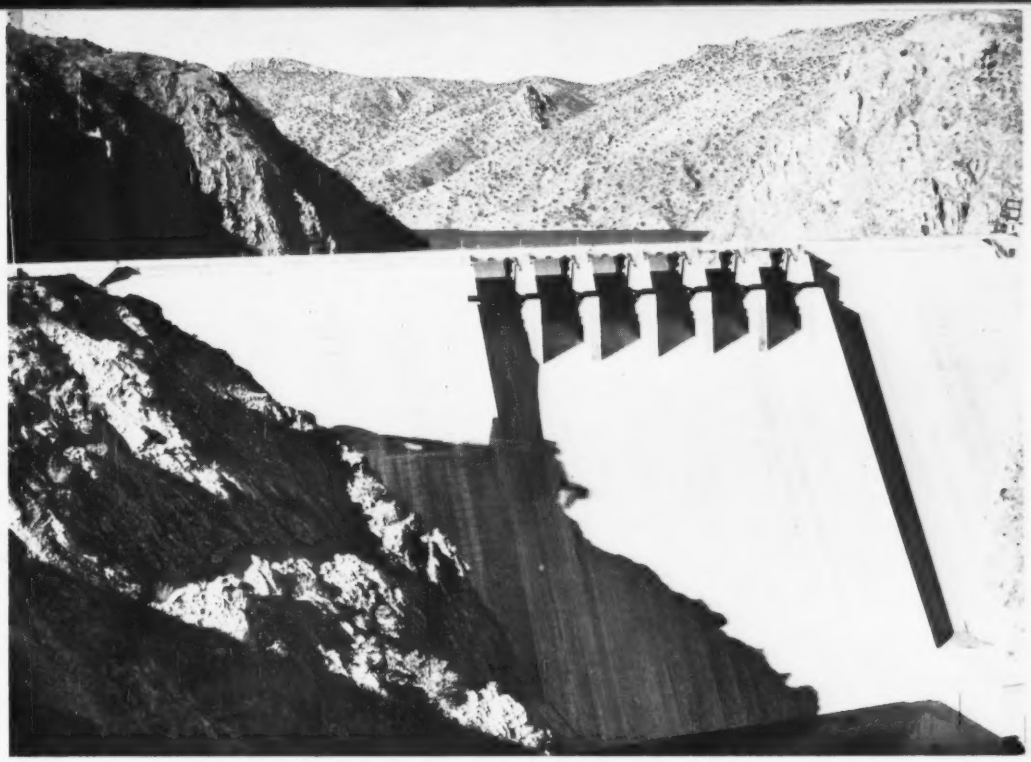
Integration with Egypt in the United Arab Republic should, however, accelerate the country's economic development and much is expected of the new Ten Year Plan, started in 1958 with Soviet aid and technical assistance. Of a projected outlay of £2,000 million, 88% will be spent on irrigation, hydro-electricity and transport.

The Plan covers the Ghab land reclamation project, the afforestation of newly irrigated areas in Lattakia Province and the erection of a nitrogen fertilizer plant at Homs. It is hoped that the Plan will result in an increase in the agricultural income of the country from its present level of £1,000 million to £1,800 million by 1970.

The nitrogen fertilizer plant to be built adjacent to the Homs oil refinery will have an annual capacity of 35,000 tonnes N in the form of lime ammonium nitrate and is due for completion in 1962. This plant can be expected to supply virtually all Syria's fertilizer nitrogen requirements for several years. The resumption of the growth of exports to this country would then be dependent on the success of the Ten Year Plan which in time would require additional foreign capital and the initiation of complementary measures covering land reform, diversification of production and education in agricultural technique.

Turkey

With her population, now 25 million, increasing at an average rate of 2.5% per annum and expected to reach 40 million by 1975, Turkey is faced with a rapidly deteriorating agricultural situation. Two-thirds of the country is semi-arid, there are wide variations



Turkey. General view of the Sariyar Dam and hydroelectric station. The waters are used for irrigation in North and Central Turkey.

in rainfall and drought is a constant threat. Of the 20.7 million hectares already under cultivation, much is land of poor quality and should never have been put to the plough. Grasslands are heavily overgrazed and with the cultivated land are encroaching on forest. Severe and widespread erosion is the result and with the unbalanced development of irrigation has led to low yields. Cereals, constituting the bulk of Turkey's agricultural output are for the most part grown on rain-fed land with yields in some years as low as 500-700kg. per hectare.

As very little surplus land remains to be profitably cultivated the future growth of Turkey's agricultural output depends on the development of irrigation and increased use of fertilizer. Little has so far been done to put water conserved in canals and reservoirs to effective use as distribution facilities are in most cases totally inadequate. The Food and Agriculture Organisation of the United Nations have estimated that by giving effect to a modest programme it will ultimately be possible to bring 4 million hectares under effective irrigation and have suggested the following irrigation schedule.

Area under full and efficient irrigation (hectares)

1960	50,000	1964	650,000
1961	200,000	1965	800,000
1962	350,000	1975	2,300,000
1963	500,000		

At an estimated cost of U.S. $1,000 for each additional hectare brought under irrigation, the annual expenditure required for this programme would be U.S. $1.5 million a year. An additional U.S. $20 million a year would be required for conservation work on arable and grazing land and for afforestation.

Nitrogen fertilizer consumption, now at an annual level of 16,000 tonnes N, has increased by 75% within the last five years, but still represents little over 0.5kg. per hectare of cultivated land. The present level of application in Egypt is 100 times greater. Domestic by-product nitrogen accounts for only 1,300 tonnes N of Turkey's annual supply. The bulk of the imports originates from the United States, West Germany and Italy and is in the form of ammonium sulphate and urea.

By 1960/61 the fertilizer works under construction at Kutahya will be in operation with

an annual capacity of 25,000 tonnes N. Lignite will be used in the manufacture of 60,000 tonnes of ammonium sulphate and 50,000 tonnes of lime ammonium nitrate in addition to ammonia and nitric acid for technical use. The new plant is being financed and erected by the West German firms of B.A.S.F. and Friedrich Uhde for Azot Sanayii T.A.S.

If the irrigated area in Turkey is increased to 4 million hectares it has been estimated that fertilizer nitrogen consumption would rise to at least 200,000 tonnes N per annum. The present rate of agricultural investment would have to be raised substantially to reverse the decline of Turkish agriculture and provide a sound basis for increased fertilizer application.

Conclusion

Despite the relatively high level of consumption in Egypt, nitrogenous fertilizer use in the Near East as a whole, which in 1958 totalled 247,000 tonnes N, is in terms of use per unit of agricultural land or of population amongst the lowest in the world. The prospects of fertilizer nitrogen in this region are determined by factors which are virtually common and which turn on the development of agriculture in these countries.

Inflexibility in the pattern of land tenure and a high degree of rural under-employment prevails in most areas and sub-division of land into units which are too small for efficient production or excessive concentration of land in large estates cultivated under share cropping arrangements, stand in the way of promoting greater efficiency. Irrigation, the key factor in expansion is still inadequate and often improperly applied, and this lack, apart from inhibiting greater crop yields, is probably the main obstacle to a rapid growth of fertilizer use. This is of course recognised but if no more than the present methods to improve agricultural efficiency remain in force, it would be unrealistic to expect more than a very slow rise in rural incomes and demand for fertilizer nitrogen.

From estimates made by the Food and Agriculture Organization of the United Nations, it is evident that with relatively little capital expenditure it should be possible to double the irrigated area by 1975, while the efficacy of irrigation systems already in operation could, in many cases, be greatly improved. Co-operation in agricultural expansion to take advantage of improved irrigation facilities and to make better use of fertilizers calls for a much higher standard of education. This in itself will provide incentive to invest in improvement. Equally, it may eliminate some of the abuses of the present fertilizer supply facilities, an example of which is that the Iraqi farmer has to pay nearly U.S. $100 for a ton of ammonium sulphate, whereas the Danish farmer, whose real wealth is ten times greater, pays less than U.S. $50.

At present the Near East represents an export market of 200,000 tonnes N which is almost exclusively met by supplies from the major nitrogen manufacturers in Western Europe, notably Western Germany, Italy, the Netherlands and Belgium. The mounting pressure of the nitrogen export surplus in Japan is extending the orbit of commercial interest beyond this industry's traditional markets in South East Asia. The major producers and established exporters of fertilizer nitrogen may well produce more efficiently and probably much more cheaply, but the new and growing indigenous producers enjoy the protection of a strong political and economic nationalism. It is evident, therefore, that the expansion or even the maintenance of the present level of nitrogen shipments to the Near East from whatever source can only be realised if the prevailing obstacles to agricultural expansion are removed.

The initiative for much of the action that is needed can only come from Governments with the advice and co-operation of international organizations for aid and development. State sponsored measures would, however, be rendered more effective by complementary action of private enterprise. Especially in practical and detailed aspects, such as handling, distribution and application of fertilizers, individual exporters or groups have much scope; they might also be prompted indirectly to promote education in agricultural and fertilizer techniques and even the provision of capital for irrigation, drainage and afforestation. Increasing industrialisation and the effective use of oil revenues are likely to encourage a higher level of agricultural activity, and the growth of fertilizer use, in particular of nitrogen, will provide the yardstick of progress.

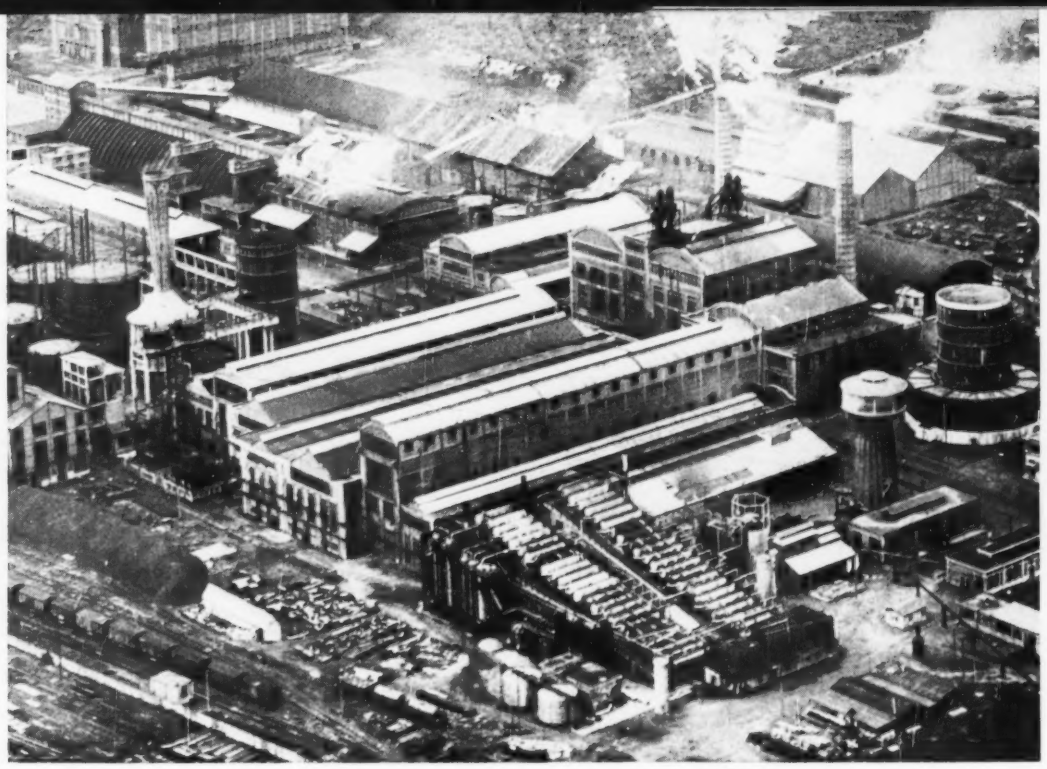
Supply · Prices · Trends

WORLD SUPPLIES of nitrogen are at a higher level than ever before, but in contrast with the position in the autumn last year overall demand appears to correspond to supplies. There are of course some instances of oversupply and export surplus, notably in Japan's Nitrogen Industry, which remains the main anxiety in an otherwise equable world market. In part the present position is attributable to a measure of restraint on the part of most major nitrogen producers and exporters, notably in Western Germany and Belgium, who limited their level of production instead of keeping pace with evident expansion of demand. Supporting factors are the severe depletion of stockpiles in Western Europe, the slightly lower level of operations in Norway due to last summer's drought and the consequent shortage of electricity, the limitations imposed on by-product ammonium sulphate production in the U.S.A. by the steel strike and a slight delay in the completion of a number of projects which, instead of making a substantial contribution to world supplies now, are not likely to do so for at least six more months. Nevertheless, world prices of fertilizer nitrogen have not advanced but the progressive price decline over the past 20 months has been arrested. A notable feature of recent months' transactions has been the increase of business transacted through brokers. Instances of severe competition appear to be confined to isolated offers by Japanese suppliers in markets outside their traditional spheres of activity in South-East Asia and to some of the lesser South American markets where in an attempt to become established various suppliers compete for relatively small tonnages. China continued buying in Western Europe during the early autumn and her purchases although secured at keen prices helped to improve the statistical position.

In the **United States** production of anhydrous ammonia declined seasonally during the summer months, but amounting to 905,000 short tons N during the period June to August, was nevertheless 20% higher than in the summer of 1958. As the result of the steel strike by-product ammonium sulphate production was reduced by four-fifths and expansion of synthetic material could not prevent stocks declining. It is estimated that the strike will have caused a loss of sulphate supplies of at least 300,000 tons. Ammonium nitrate production, averaging about 220,000 short tons monthly, reflected the heavy demand of the preceding fertilizer season and the introduction of progressive autumn price increases applied by the manufacturers, in contrast with the single major increase scheduled in September 1958, discouraged a sudden spurt in demand. Fertilizer activity caused a high level of nitric acid production to be maintained and the lack of industrial demand due to the strikes in steel, copper and lead, did not sensibly affect the overall market.

At the end of September Valley Nitrogen Company started deliveries of anhydrous ammonia from the new $9½ million plant at Helm in California. Collier Carbon & Chemical Company at Brea, Calif., whose sales are affected by this new production, does not appear to have made any change of plans to raise capacity by 30,000 tons N by 1961. At Wilmington, Del., the company, an 80% subsidiary of Union Oil Company of California, is building an ammonium sulphate plant. Nearing completion is the plant extension by Co-operative Farm Chemicals at Lawrence, Kan., where capacity is being raised 56% to 78,000 N primarily for the manufacture of urea and urea-nitrate solutions.

In the **United Kingdom** production difficulties have been experienced by Shell Chemicals Limited new anhydrous ammonia plant at Shell Haven which prevented the designed level of output being reached. Imperial Chemical Industries at Ardeer are building a nitric acid plant to produce weak acid by the intermediate oxidation system. It will replace existing plants of which two are of the DuPont pressure oxidation type and a third which is an atmospheric pressure oxidation unit. A new process has been patented by Chemical Con-



Belgium. Aerial view of the Willebroeck works of Ammoniaque Synthétique et Dérivés.

struction (G.B.) Co. Ltd. for the neutralisation of sulphur in flue gases by means of ammonia injection. The impact on the economics of the nitrogen industry of the large-scale application of this process could be far-reaching as it is estimated that in the U.K. alone the neutralisation of sulphur in power station flue gases would give rise to the manufacture of some 11 million tons of ammonium sulphate annually entailing the use of about ¼ million tons of anhydrous ammonia.

In **Eire** the Government has postponed the construction of the Shannonbridge plant which was to be based on the use of peat. The decision was taken in the light of plentiful low-priced world supplies.

On the **Continent of Europe** there has been some curtailment of production. In the late summer unstable export markets and anxiety about domestic autumn sales prospects due to the effect of the drought throughout N.W. Europe decided several major producers to limit output and at the same time to reduce stocks.

In **Norway** the small (10,000 tonnes per annum N) Notodden plant ceased operating temporarily due to lack of hydro-electric power. In **France** the mounting northward pressure of Lacq natural gas supplies had disturbed the balance of the coal gas industry and caused an increased output of by-product ammonia, and it is estimated that current production is at an annual rate of close on 600,000 tons N. Addition to ammonia capacity is progressing rapidly and up to 100,000 tons N new capacity is expected to be in operation by 1961/62. The liberalisation of imports of nitrogenous fertilizer into **Spain,** following this country's joining O.E.E.C., has been accompanied by the imposition of 15% duty to protect the growing domestic industry. The latest project, a 90,000 tons N plant to be built by the R.E.P.E.S.A. oil refinery at Cartagena, is due for completion in 1962. Expansion of the urea capacity by Carbochimique S.A. at Tertre, **Belgium,** and the decision by A.N.I.C. to start building a urea plant at the Ravenna works in **N. Italy** will substantially augment urea supplies in Europe, which by the end of next year should arise at an annual rate of about 150,000 tons.

Negotiations are in progress between the

Federal Government of Rhodesia and African Explosives and Chemicals (Rhodesia) Limited, with a view to establishing a £9 million nitrogen fertilizer plant near Salisbury. At present the Dominion's entire requirements are imported.

In the **Middle East and Far East,** the principal export markets, substantial sales by tender have been effected. In addition, China continued purchasing in Western Europe. The Indian tender secured about 60,000 tons N whilst the tenders in South Korea declared in October totalled over 110,000 tons N. For the fiscal year 1960 agreement has been reached between the South Korean Government and I.C.A. officials whereby 60% of next year's procurement will be through the Government (OSROK) and 40% through the commercial channels of the Bank of Korea. Some U.S. $21.7 million is to be expended and on all types of nitrogen fertilizers, the only restriction applying to calcium cyanamide purchases which are to be limited to 20,000 tons. A decline in the level of imports into Formosa is expected as the result of the imminent start of the 84,000 tons urea plant at Nanking, near Taipei. Also expanding is Taiwan Fertilizer Company's ammonium phosphate output which will attain 150,000 t.p.a. on completion of the construction programme now under way.

FREIGHT

The advance of ocean freight rates in September and October as the result of the sudden demand for grain tonnage to Western Europe where the exceptional and persistent summer drought had created a heavy demand for coarse feed grains, abruptly ended. Re-entry of some laid-up tramp tonnage and the use of tankers for dry-weight cargo were partly contributory, but essentially the weight of laid-up tonnage, and new tonnage leaving shipyards or still on the stocks continue to prevent freight rates becoming established at higher levels.

An indication of current rates for vessels of 10,000-12,000 tons is as follows :—

To	*From*		
	Japan	*U.S.A.*	*W. Europe (equivalent)*
China	—	—	64s. 6d.
South Korea ...	$3	$19*	57s.
India (E. Coast)	$7.50	—	51s.
Central America...	—	$13*	40s.

* U.S. flag.

PRICES

World prices have stabilised following the severe reduction which accompanied the disposal of stocks in Western Europe. Now that the supply position is tighter, some Western European producers have no supplies readily available for delivery before the New Year; the tone of the market is firm although there is no evidence of prices advancing. Despite isolated instances of severe competition, as in some small South American markets, and the continued export surplus in Japan the outlook is now more confident.

Domestic Prices

U.S.A.

Seasonal advances of price schedules have been announced by U.S. manufacturers. As indicated above this year ammonium nitrate prices will advance over five months from September at $1 per month to $68 in January. The price basis of anhydrous ammonia in California has changed following the decision of Best Fertilizer Company to change from an ex-works price of $66 to a delivered price of $72 to consumers anywhere in the Central Valley of California. This took effect on the 1st October. As yet none of Best's competitors have followed this development, but competition remains strong. Ruling prices are as follows :—

	Price per short ton f.o.b.
Coke-oven ammonium sulphate ...	$32 in bulk
Synthetic ammonium sulphate ...	$35 in bulk
Ammonium nitrate (33.5% N) ...	$66 in bulk
Calcium Cyanamide	$57 in bags
Nitrogen solutions (40.8% N; basis 100%)	$124 in tank cars

The price of lime ammonium nitrate and sodium nitrate is $44 per ton f.o.b. works or port and bagged material in car-load lots is $48. Fertilizer grade urea (46% N) is quoted at $103 per short ton delivered. Anhydrous ammonia (fertilizer grade) in the Eastern U.S.A. is quoted at $86 per short ton in tank cars ex works, and refrigeration grade $2.50 more.

United Kingdom

Current quotations for material delivered to farmers' nearest railway station are :—

	Per ton	*Subsidy*
Ammonium sulphate (21% N)	£20 11s. 0d.	£9 19s. 6d.
Nitro-Chalk (15.5% N) ...	£18 10s. 0d.	£7 7s. 3d.
Nitro-Chalk (21% N)	£24 0s. 0d.	£9 19s. 6d.
Kaynitro (16%N-16% K_2O)	£26 17s. 6d.	£7 12s. 0d.

Nitra-Shell (23% N)	£26 5s. 0d.	£10 18s. 6d.
Sodium Nitrate (16% N)	£23 18s. 0d.	£7 12s. 0d.

No decision has yet been reached regarding the application for removal of the import duty which in the case of ammonium sulphate amounts to £4 per ton.

Western Germany

	DM per tonne N				
	Sept.-Oct.	*Nov.*	*Dec.*	*Jan.*	*Feb.-June*
Ammonium sulphate (21% N) ...	1,130	1,140	1,150	1,170	1,190
Ammonium sulphate nitrate (26% N)	1,140	1,150	1,160	1,180	1,200
Lime ammonium nitrate (20.5% N)	1,160	1,170	1,180	1,200	1,225
Calcium nitrate (15.5% N) ...	1,300	1,310	1,320	1,340	1,360
Calcium nitrate (16% N) ...	1,350	1,360	1,370	1,390	1,400
Urea (46% N) ...	1,130	1,140	1,150	1,170	1,190

Export Markets

Ammonium Sulphate

Current prices in export markets range from $31 to $36 per tonne f.o.b. in bulk. In the early autumn sales by Western European producers to China were reported at prices equivalent to $33.50 per tonne f.o.b. in bags and more recently at $36, but possible differences in packing makes comparison difficult. In the South Korean tender of 9th October for 197,000 tonnes, Western German, Belgian and Italian suppliers secured orders for 80,000 tonnes at $37.50 per tonne f.o.b., 90,000 tonnes Japanese material was sold at $41.80 and up to $44.25 per tonne f.o.b. was quoted by Canadian and U.S. suppliers. For shipment in U.S. flag vessels c.&f. quotations ranged from $54.35 to $55.60 and from $44.70 to $45.50 in non-U.S. flag tramps. More recently Pakistan purchased 20,000 tonnes ammonium sulphate from Italy at $44.40-$44.50 per tonne c.&f. in bags and 10,000 tonnes from Austria at $43.20 per tonne c.&f. in bags.

Ammonium sulphate nitrate from Western Germany was sold to South Korea at $45.60 per tonne f.o.b. Its unit price is fractionally lower compared with corresponding sales of ammonium sulphate.

Ammonium Nitrate

Current quotations range from $65 to $69 per tonne f.o.b. The lowest price recorded recently was $57.95 for 2,000 tons Japanese material to South Korea. In the same tender U.S. suppliers quoted $69.50 to $73.70 per tonne f.o.b. Small quantities of ammonium nitrate from Eastern Europe, notably Bulgaria, are offered in the U.K. at the equivalent of $67 per tonne f.o.b. on the basis of 34%N. Belgian lime ammonium nitrate (10,000 tonnes) was sold in South Korea at $36 per tonne f.o.b.

Urea

Few offers of this material are at present in evidence. Even Japanese material, which is known to be in plentiful supply, is surprisingly not being pressed on markets.

The current export price is $78-$80 per tonne f.o.b. Actual Japanese prices, taking account of some deliveries with relatively high biuret content, are lower. The lowest price recorded is $73.77 for 1,500 tonnes sold by Shell to South Korea. In the same tender 50,000 tonnes Japanese urea was sold at $80.70 per tonne f.o.b. and 8,000 tonnes U.S. material at $105.

INDIA

FURTHER STEPS have been outlined in the expansion of India's nitrogen industry under the Third Five Year Plan whereby production capacity will exceed one million tons N by 1965. Work is at present in progress on the erection of three major nitrogen plants, at Nangal, Neyveli and Rourkela, and on three smaller plants at Varanasi, Durgapur and Calcutta. This additional capacity should be in operation by 1962 and with the existing works at Sindri, Mysore and Alwaye India's total capacity will then amount to 400,000 tons N. The plans now announced provide for the addition of a further 560,000 tons N by 1964. Under this programme, ten new plants are to be built and two others will be extended.

Plants in Operation

	Annual Capacity (tons N)	*Products*
Sindri	117,000	Ammonium nitrate Lime ammonium nitrate Ammonium sulphate Urea
Alwaye	10,000	Ammonium sulphate Ammonium phosphate
Mysore	1,000	Ammonium sulphate

Plants under Construction			
Neyveli	....	70,000	Urea
Nangal	....	80,000	Lime ammonium nitrate
Rourkela	....	80,000	Lime ammonium nitrate
Calcutta	....	10,000	Ammonium phosphate
Varanasi	....	20,000	Ammonium chloride
Durgapur	....	13,500	Ammonium sulphate
Construction Projected			
Durgapur	....	66,500	Ammonium sulphate Ammonium nitrate
Trombay	....	90,000	Urea Nitrophosphate
Andra Pradesh	....	80,000	Urea Nitrophosphate
Assam	....	5,000	Urea Ammonium sulphate
Udhampur	....	30,000	Ammonium sulphate
Madhya Pradesh (Itarsi or Bhilai)		50,000	Ammonium nitrate Urea
Rajasthan	....	90,000	Ammonium sulphate
Mysore	....	70,000	Ammonium phosphate
Koyna	....	50,000	Ammonium phosphate
Madras	....	8,250	Ammonium sulphate

The Alwaye plant is to be extended to an annual capacity of 30,000 tons N while a synthesis unit to be installed at Durgapur will raise the capacity of these works to 80,000 tons N p.a. In addition it is planned to raise the output of by-product nitrogen, now at an annual level of 6,000 tons, to 16,000 tons a year by 1963. Of the capacity in operation, under construction or projected, 34% will be based on the use of coke-oven gas, 19% on the use of coal and lignite, 21% on electrolytic hydrogen, 16% on fuel oil, 9% on fuel oil or refinery waste gas and 1% on natural gas.

Interior view of the ammonium sulphate silo at the Government owned fertilizer plant at Sindri.

	tons N		tons N
Coke-oven gas	**328,000**	**Electrolysis**	**200,000**
Sindri		Nangal	
Madhya Pradesh		Koyna	
Mysore I		Mysore II	
Rourkela		**Fuel oil**	**158,000**
Durgapur		Alwaye	
Total gasification of coal and lignite	**180,000**	Varanasi	
		Calcutta	
Neyveli		Rajasthan	
Udhampur		Madras	
Andra Pradesh		**Fuel oil or refinery waste gas**	**90,000**
Natural gas	**5,000**		
Assam		Trombay	

Outlook

Almost entirely State controlled and based on a variety of raw materials, the Indian nitrogen industry will by 1965 be one of the five largest in the world. The projected expansion of capacity and production is not, however, in step with the planned increase in nitrogen fertilizer consumption. The following table shows India's nitrogen balance since 1951 and her projected production and requirements until 1964:

	(000 tons N)		
	Production	*Consumption*	*Imports*
1951/52	10.7	50.9	20.7
1953/54	64.9	84.9	25.5
1955/56	79.9	144.6	37.6
1957/58	81.9	184.0	94.0
1959/60	100.0*	400.0*	300.0†
1961/62	300.0*	600.0*	300.0†
1963/64	750.0*	800.0*	50.0†

* = planned † = requirements

In the immediate future India will provide a substantial market for nitrogen exports, but this can be expected to contract sharply after 1963. An increased availability of foreign exchange and possible delays in the completion of construction programmes may temporarily sustain the level of imports. Nevertheless the Government firmly intends as far as possible to meet the country's nitrogen requirements with domestic supplies, which in view of the considerable potential growth of this market must have a far-reaching impact on areas with an exportable surplus. Unofficial sources indicate that the development of the Indian nitrogen industry is planned to raise annual capacity to two million tons N by 1975.

AIKMAN [LONDON] LTD.

Annual Report on the Nitrogen Industry

(All figures in Metric Tons)

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7th December, 1959.

We announced in our Half-Yearly Report last June that future issues of our report would, by agreement with British Sulphur Corporation Limited, be embodied in this magazine. This, our Annual Report, is the first so to appear. As a result of the access to the Statistical Department of the British Sulphur Corporation which is now available to us some figures of Production and Consumption for the years 1955/56 to 1957/58 have been revised although in most cases the amendments are small. Our figures for 1958/59 have been brought up-to-date and our estimates for 1959/60 have now been included.

World production and consumption of Nitrogen continue to increase, production in 1958/59 by 9½% over 1957/58 and consumption by 7%. For Europe and Egypt alone the increase was greater; production up nearly 12% and consumption 8%. We estimate that during 1959/60 production and consumption will increase by 6½% and 5% respectively and that therefore the excess of production over consumption will be 5½%.

We consider the present stock position generally to be satisfactory from producers' point of view. The prolonged steel strike in the U.S.A. is creating short supply in that country and has enabled Canadian producers to increase their sales there. In Europe the determination to move stocks at any price has had its effect and large quantities have been exported reducing stocks to a minimum. However, in spite of recent sales to Korea, India and other countries, the stock position in Japan must still be causing concern and some rationalisation or curtailment of production can be expected.

In our Half-Yearly Report issued June 1959 we stated that prices were then at a low level and although in the immediate future they may go lower, we foresaw the bottom being reached and a possible rebound. We were correct in the immediate outlook in that prices have gone lower but we did not foresee the extent to which they would fall. However, it is now our opinion that the market has turned and that from now on we can expect no further lowering of prices, in fact more probably the reverse.

During the last six months, however, producers, in an endeavour to move their stocks at all costs, have done so at ever reducing prices, which we consider was unnecessary.

In Spain, consequent to that country's entry into the O.E.E.C. as a full member, imports have been liberalised, which in effect means that importers are now free to buy from where they like and at a price at which they can negotiate. Since liberalisation an import duty has been imposed by the Spanish Authorities in order to protect their national production and because this is based on the value of gold it is not easy to calculate the exact import duty. However, at to-day's value it is about 15%. Should the prices of exporting countries to Spain further be reduced, undoubtedly the duty will be increased in order to maintain protection of the Spanish producers and for this reason it would seem quite pointless for exporting countries to make any further reductions. In the last sales by tender in April of this year, European producers sold ammonium sulphate at $37. Since then, sales have been effected at $35. Canadian producers sold two cargoes at a price believed to be $31.75 FOB. Since the sale, however, freight rates have risen considerably and whoever took the freight risk must stand to make a loss.

Freight rates generally have made a good recovery during the past three months and if this trend continues the Japanese will be in a favourable position to sell in the Far East whilst the Americans will be at a disadvantage for all their exports except in the Caribbean, Central and South America.

In Korea the lowest offer made was from the Shell Chemical Company of 1,500 tons of Urea at $73.77 FOB or $88.77 C.&F. U.S.A. liner. Japan offered 50,000 tons of Urea at $80.70 FOB, $89.20 C.&F. U.S.A. liner or $83.70 non-U.S.A. liner. Shell sold their 1,500 tons on the cost and freight basis and the balance of 48,377 tons was awarded to Japan. Of this tonnage approximately 30,000 tons was awarded at $89.20 C.&F. U.S.A. liner and 18,000 tons at $80.70 FOB Japanese Port. Japan was also awarded 2,000 tons of Ammonium Nitrate at $57,95 FOB Japanese Port. Other offers made were Ammonium Nitrate from $57.95 FOB, Ammonium Sulphate Nitrate $45.60 FOB, Calcium Ammonium Nitrate from Belgium $36 FOB and Sulphate of Ammonia from a variety of European Producers at the uniform price of $37.50 FOB, although the cost and freight prices varied from $54.35 to $56 C.&F. U.S.A. tramp and $44.70 to $45.50 C.&F. non-U.S.A. tramp.

In India, the Japanese sold 31,300 tons of Urea at £31/3/7 and 108,000 tons of Sulphate of Ammonia in 100 kilo jute bags at £15/2/9 C.&F. landed. Although the Europeans sold some Urea at £30/13/-, Ammonia Sulphate Nitrate at £19/11/1 and Calcium Ammonium Nitrate at £14/9/6, it was the low Japanese price for Sulphate of Ammonia that set the pace for general price reductions. Somewhat naturally the Chinese refused to pay the old price and forced the Europeans to reduce their price to £11/17/9 for Sulphate of Ammonia and £11/3/9 for Calcium Ammonium Nitrate FOB in bags. This price is £1/15/- lower than that prevailing six months ago.

In the most recent Pakistan tender offers of Sulphate of Ammonia, in bags, were made by a number of producers in Europe, including East Germany, Japan and Australia, varying from $44.60 C.&F. liner terms. Negotiations then commenced as a result of which 20,000 tons were purchased from Italy, half at $44.40 and half at $44.50 and a further 10,000 tons from Austria at $43.20, all in 50 kilo jute bags C.&F. liner terms.

In Venezuela a quantity of Sulphate of Ammonia has been sold by the Belgians at $42 C.&F. Puerto Cabello in 50 kilo jute bags.

In Egypt a tender for 100,000 tons of Calcium Ammonium Nitrate was withdrawn because of the lack of foreign currency but as we go to press we learn that some European sales have been concluded at $39.20 C.&F. Alexandria in 75 kilo bags.

The following are our revised estimates of production and consumption in the World excluding the U.S.S.R. from 1955/56 to 1959/60 and in terms of thousands of tons of pure Nitrogen:—

	Production		Consumption	
	Agriculture	Industry	Agriculture	Industry
1955/56	6,823	1,245	6,307	1,245
1956/57	7,278	1,370	6,977	1,370
1957/58	7,983	1,510	7,773	1,510
1958/59	8,768	1,630	8,327	1,630
1959/60	9,342	1,715	8,744	1,715

Details of individual countries are on the following page.

None of these figures include the U.S.S.R. but are personal estimates of actual production in thousands of metric tons of pure Nitrogen as follows:—

1955/56	1956/57	1957/58	1958/59
627	710	750	800

Consumption in U.S.S.R. is believed to have been greater than these figures show, owing to imports from Eastern Germany.

CHILEAN NITRATE

Production in Chile has been favoured by steady labour conditions and in the absence of strikes amounted in the year ended 30th June, 1959, to 202,000 tons Nitrogen—only a little less than in the previous year. Production at the mechanised plants was well maintained but due to increasing costs, the Shanks producers have found themselves obliged to cut their production by about 10%.

With present intense competition profits for the current year will probably not come up to expectations but the overhaul of the industry by continued large expenditure on plant modernisation points to a healthier outlook. The development of the Solar Evaporation Process by the Guggenheims is being actively pursued and the mechanisation of the Tocopilla Nitrate Port on which work was started earlier this year is a further demonstration of buoyant confidence in this time-tested industry.

REVISED ESTIMATES OF WORLD NITROGEN PRODUCTION AND CONSUMPTION IN THOUSANDS OF METRIC TONS OF PURE NITROGEN

(Excluding U.S.S.R.)

	1955/56		1956/57		1957/58		1958/59		1959/60	
	Prod.	Con.	Prod.	Con.	Prod.	Con.	Prod.	Con.	Prod	Con.
EUROPE AND EGYPT										
United Kingdom	450	406	455	435	465	435	495	510	570	510
France and Colonies	440	443	488	508	557	575	612	594	670	600
Belgium and Luxembourg	290	80	280	95	250	95	290	95	290	95
Holland	303	186	330	194	400	215	415	215	420	225
Norway	191	48	229	52	231	54	250	57	206	50
Italy	343	245	420	265	425	278	530	300	630	300
Austria	130	32	135	39	159	45	163	45	165	45
Germany—West	912	627	1,065	697	1,210	710	1,345	725	1,370	735
Switzerland	24	24	23	23	24	24	25	25	24	24
Denmark	—	89	—	99	—	76	—	99	—	100
Sweden	39	97	33	92	45	90	48	100	50	110
Finland	17	37	23	37	31	50	35	54	38	55
Spain	52	190	49	180	52	195	65	200	70	220
Portugal	20	51	24	50	20	53	35	71	40	75
Greece	—	42	—	55	—	61	—	77	—	85
Turkey	2	10	1	10	6	19	10	20	10	30
Jugoslavia	10	35	12	57	10	82	15	98	25	105
Iceland	7	5	7	7	7	7	7	7	8	8
Eire	—	15	—	16	—	16	—	17	—	18
Germany—East	310	230	346	265	355	300	370	305	390	330
Poland	168	173	180	180	210	200	255	240	265	255
Czechoslovakia	70	90	74	80	82	100	110	115	115	120
Hungary	18	25	18	44	20	45	25	55	30	60
Bulgaria, Rumania and Sundries	25	15	25	17	25	40	30	45	35	50
Egypt	32	115	30	138	35	150	35	170	35	190
Total for Europe and Egypt	3,853	3,310	4,247	3,635	4,619	3,915	5,165	4,239	5,456	4,395
OTHER COUNTRIES										
U.S., Puerto Rico and Hawaii	2,700	2,500	2,735	2,735	2,950	2,950	3,100	3,100	3,300	3,250
Canada	209	56	220	70	305	85	310	90	320	95
Central and South America (excluding Colonies)	60	164	70	170	70	250	80	290	100	310
British Colonies and Sudan	—	60	—	75	—	80	—	105	10	115
Australia and New Zealand	21	32	22	35	24	37	24	40	26	44
Japan	720	630	830	640	920	650	950	680	955	685
India	80	145	85	155	82	184	95	220	100	260
Pakistan	—	8	—	30	5	35	10	30	10	35
Ceylon	—	22	—	23	—	24	—	25	—	26
China	86	262	120	345	180	500	250	570	300	620
Taiwan	17	75	18	95	22	117	70	110	80	120
Korea	20	132	35	140	40	216	60	225	90	250
Israel	2	12	8	12	10	12	10	13	15	18
Africa (excluding Egypt and British Colonies)	42	57	45	70	45	100	45	85	55	100
Philippines	7	30	7	33	10	38	9	39	10	40
Indonesia	—	25	—	30	—	30	—	30	—	25
Sundries	18	15	18	35	18	40	18	45	20	50
Chile	233	17	188	19	193	20	202	21	210	21
GRAND TOTAL	8,068	7,552	8,648	8,347	9,493	9,283	10,398	9,957	11,057	10,459
Less for Industrial Purposes	1,245	1,245	1,370	1,370	1,510	1,510	1,630	1,630	1,715	1,715
TOTAL FOR FERTILIZERS	6,823	6,307	7,278	6,977	7,983	7,773	8,768	8,327	9,342	8,744

Details of estimated Industrial Production and Consumption are as follows:—

	1955/56	1956/57	1957/58	1958/59	1959/60
United Kingdom	110	120	120	120	125
France	40	50	60	65	70
Germany—West	150	155	160	165	170
Germany—East	20	30	30	40	45
Rest of Europe	75	100	110	130	145
United States	750	800	900	950	980
Canada	15	20	25	30	35
Japan	50	60	80	90	100
Other Countries	35	35	35	40	45
TOTAL	1,245	1,370	1,510	1,630	1,715

The following table gives a revised estimate of exports from the producing countries and imports by the consuming countries for the years 1955/56, 1956/57,1957/58, 1958/59.

	EXPORTS				IMPORTS			
	1955/56	1956/57	1957/58	1958 59	1955/56	1956/57	1957/58	1958/59
United Kingdom	26	11	64	35	6	11	21	40
France	17	6	35	14	28	16	19	17
Belgium and Luxembourg	153	126	201	204	6	11	15	12
Netherlands	140	162	189	200	24	20	18	9
Norway	143	161	169	180	—	—	—	1
Italy	89	107	128	217	9	8	17	8
Austria	90	114	108	120	1	1	1	1
Germany—West	300	375	525	525	5	3	3	3
Switzerland	—	—	—	—	—	—	—	—
Denmark, Sweden and Finland ...	—	—	—	—	144	175	172	160
Spain and Portugal	—	—	—	—	166	155	181	240
Germany—East	84	80	85	90	—	—	—	—
Poland	5	10	5	10	20	5	—	—
Near East	—	—	—	—	26	26	28	28
Egypt	—	—	—	—	90	120	150	160
British Colonies and Sudan ...	—	—	—	—	63	65	70	75
United States	180	268	227	205	282	294	305	295
Canada	140	160	220	280	6	4	15	15
Japan	159	232	311	320	—	—	—	—
India, Pakistan and Ceylon ...	—	—	—	—	60	100	100	100
Australia and New Zealand ...	—	—	—	—	9	12	11	12
Africa (excluding Egypt and British Colonies	—	—	—	—	42	50	70	90
China	—	—	—	—	150	205	270	320
Taiwan	—	—	—	—	62	83	117	118
Korea	—	—	—	—	112	159	146	140
Chile	210	172	195	190	—	—	—	—
South and Central America and Other Countries	—	—	—	—	170	300	425	480
TOTAL	1,736	1,984	2,462	2,590	1,481	1,823	2,154	2,324

AIKMAN (LONDON) LTD., BROKERS

NITROGEN IN BELGIUM

Zandvoorde Works of the Union Chimique Belge

AN EXTENSIVE programme of modernisation and expansion of the works of the Union Chimique Belge at Zandvoorde near Ostend was completed towards the end of 1958. Capacity at this plant has been more than doubled and the annual output raised to 60,000 tons N.

The Zandvoorde works were built in 1930 and all the hydrogen required for the ammonia synthesis was obtained from coke-oven gas; to-day 50% of the hydrogen is derived from heavy fuel oil in a thermal cracking unit.

The expansion programme upon which Union Chimique Belge embarked in 1956 called for the following steps :

(a) extension of the battery coke-ovens and modernisation of the existing gas treatment plant

(b) erection of new facilities to obtain, from fuel oil, the amount of hydrogen equivalent of 100 tons/day of ammonia

(c) erection of a new 200 tons/day synthesis unit equipped with two new vertical compressors.

Hydrogen from coke oven gas

The coke-oven gas is first purified in the coking plant by conventional methods; after being stripped of its light oil fractions it is passed through purifying boxes where the nitrous oxides are removed, then it is wet scrubbed with an ammonia solution to eliminate hydrogen sulphide and carbon dioxide.

Compressed to 12 kg.p.sq.cm., the purified gas, containing approximately 58 to 60% hydrogen, goes through a final step of CO_2 removal and is then fed to a conventional Linde low temperature hydrogen extraction unit.

In this unit, the gas is cooled by steps to −195° C., the separated hydrogen being finally scrubbed with liquid nitrogen. The final product is composed of three volumes of hydrogen for one of nitrogen. At the same time, a 40% ethylene fraction is recovered in addition to fractions of methane and carbon monoxide; the latter are used as fuel in the coke-ovens.

Aerial view of the installations at Zandvoorde.

Hydrogen from gasified fuel oil

By the thermal cracking with oxygen of heavy fuel oil in two Koppers gasifiers working at atmospheric pressure, a gas containing approximately 7% CO_2, 47% CO and 44% H_2 is obtained. The hot gases leaving the combustion chamber are passed through three waste heat boilers, then through a series of cyclones and washers where residual carbon, produced in the cracking operation, is removed.

After a soda wash which eliminates traces of sulphur dioxide, the gas is compressed to 92.5 p.s.i.g. in an axial flow compressor. In order to ensure prolonged life of the conversion catalyst, a very thorough desulphurization is necessary. Accordingly, the compressed gas is washed under pressure by the Alkazid process. The Alkazid washing solution is continuously regenerated and recycled, while the by-product hydrogen sulphide is burnt in a small 10 tons/day (100% H_2SO_4) wet catalyst type sulphuric acid unit.

After being saturated with steam, the gas is fed into two parallel shift converters in which carbon monoxide reacts with water vapour to yield hydrogen and carbon dioxide. The conversion is achieved in two stages, CO_2 is removed in two absorbers, at a temperature of betwen 55 and 60° C., by a solution of sodium carbonate activated with arsenic. The solution from the bottom of the absorbers is lowered to atmospheric pressure, regenerated by aeration and recycled. After conversion and CO_2 absorption, the gas contains around 91% H_2; it then goes through a final purification step in a Linde unit, where it is cooled and washed with liquid nitrogen; when it leaves the unit, it contains 25% N_2 and 75% H_2.

Production of oxygen and nitrogen

The supply of nitrogen is produced in a Linde-Frankl air separation unit fed with filtered air at a pressure of 80 p.s.i.g. This unit provides all the oxygen required for the heavy fuel thermal cracking plant, the liquid nitrogen used for processing the gas produced in the Koppers plant and finally a sufficient quantity of pure nitrogen to supply the conventional Linde coke-oven gas system.

Synthesis

The synthesis gas, N_2+3H_2, produced by the coke-oven gas and Koppers gasification systems is compressed to a maximum pressure of 7,100 p.s.i.g. in two vertical compressors. This gas is fed to the ejector of a Casale type synthesis unit where it is converted to anhydrous ammonia. The capacity of this new synthesis unit is 200 tons a day. The ammonia produced is used in the manufacture of ammonium sulphate, nitric acid and ammonium nitrate.

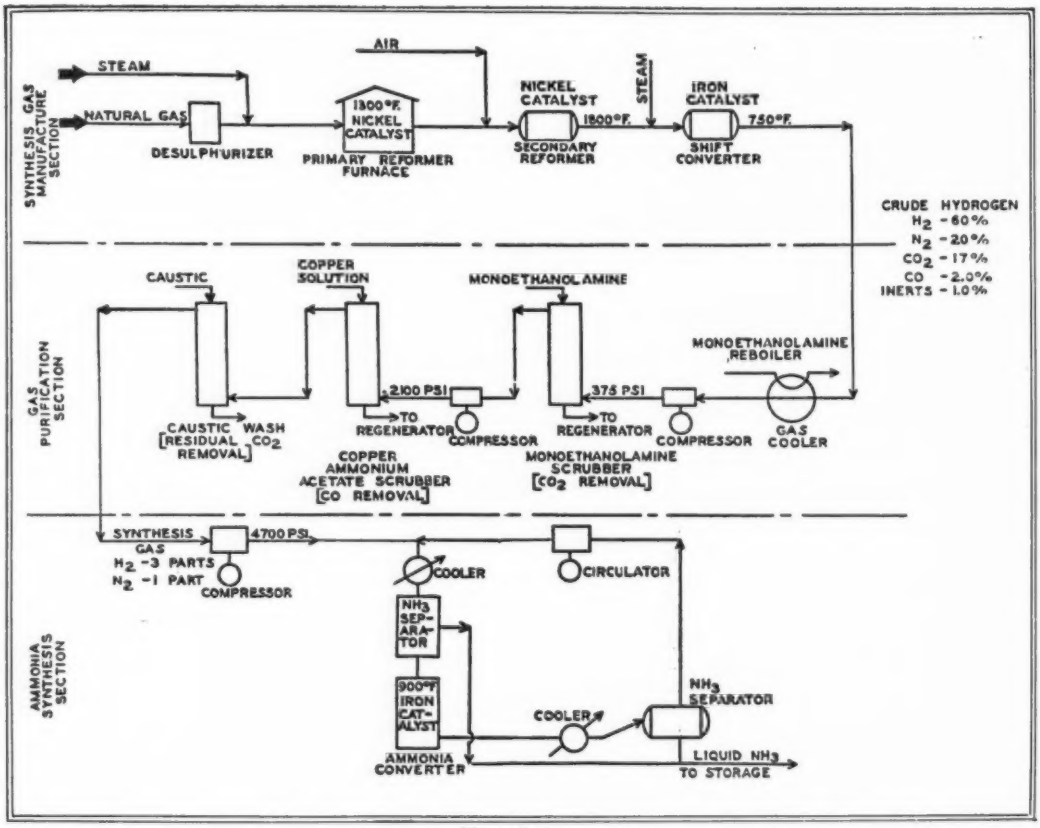
SOLAR NITROGEN AT LIMA, OHIO

MIDWAY BETWEEN Chicago and Pittsburgh and about 15 miles south of Detroit, the Lima, Ohio plant of Solar Nitrogen Chemicals Inc. was completed late in 1955. With an annual capacity of 100,000 tons of nitrogen, the Lima works produce ammonia, ammonium nitrate, urea and nitrogen solutions and has become one of the most important plants of its type in the United States.

The plant is operated by the Sohio Chemical Corp. for Solar Nitrogen Chemicals Inc. The latter company was formed in 1959 as a jointly owned subsidiary of the Standard Oil Co. (Ohio) and the Atlas Powder Co. of Wilmington, Del. to acquire the nitrogen and petrochemical facilities at Lima. The Sohio Chemical Co., itself a subsidiary of the Standard Oil Co. (Ohio), is also responsible for all marketing.

Synthesis Gas Manufacture

The principal raw material employed in the nitrogen plant at Lima is natural gas. Refinery waste gas is the alternative source of hydrogen for ammonia synthesis. After removal of sulphurous impurities, the first step in reforming the hydrocarbon feed gases is carried out in a furnace containing stainless steel tubes filled with a reduced nickel oxide catalyst. Additional heat required to maintain the reaction temperature at about 1,300°F is



Flow diagram.

supplied by burning natural gas in the furnace.

In the next step the effluent from the primary furnace enters a secondary reformer together with air. The same type of nickel catalyst is used as in the primary furnace but the temperature is maintained at about 1,800°F and no outside heat is required.

The hot gases from the secondary reformer are quenched to a temperature of approximately 750°F and are reacted with additional steam in a shift converter as the third step in the formation of hydrogen. In the shift converter the greater part of the carbon monoxide formed in the two previous steps is converted to carbon dioxide by reaction with steam over an iron oxide catalyst. Additional hydrogen is liberated from the steam used in this reaction.

Gas Purification

Raw synthesis gas from the shift converter is cooled by heat exchange, compressed to approximately 300 lbs. per square inch and fed to the purification system. At this point the principal contaminants are carbon dioxide (about 17%) and carbon monoxide (about 2%). Carbon dioxide removal is effected by absorption in monoethanolamine, a system which is not only highly efficient, but which removes traces of oxygen in the gas and affords a pure carbon dioxide by-product suitable for use in the manufacture of urea or dry ice.

Purified to a carbon dioxide content of 0.1% or less, the synthesis gas is compressed to 2,100 lbs. per square inch and washed with a complex solution of copper, ammonia and acetic acid to remove the carbon monoxide. Small splatterings of a deep blue colour may be noticed from equipment in which this copper solution is handled. Special care is taken, however, to make sure that this potentially

troublesome source of stream pollution cannot become a nuisance and all equipment handling the solution is enclosed within areas paved and curbed to catch all drips and leaks. Any overflow from the sump collecting leakage is transported to a purifying system that will remove the copper solution to ensure that it is not discharged with the plant effluent.

Ammonia Synthesis

The purified gas is compressed to 4,700 lbs. per square inch and combined with the recycled gas from the ammonia synthesis unit. The combined gases are then cooled to a temperature at which residual ammonia in the recycle gas will condense. This ammonia condensation removes any traces of water present in the fresh synthesis gas and thus performs the final removal of ammonia catalyst poisons.

The feed gas is then circulated to the synthesis reactors where the hydrogen and nitrogen are combined over an iron catalyst at a temperature of about 900°F. The incoming gases are preheated by the hot exit gases. The latter contain about 20% NH_3, the balance being unconverted nitrogen and hydrogen.

Approximately 80% of the ammonia in the effluent gas is removed directly by condensation in an air cooler followed by further condensation in a water cooler. The unreacted hydrogen and nitrogen and uncondensed ammonia are compressed back to 4,700 lbs. per square inch completing the cycle by joining the fresh synthesis gas. The bulk of the inert gases, such as methane and argon, is removed in solution with the ammonia product and the balance is removed through a small purge stream taken from the cycle. The liquid anhydrous ammonia product from the two condensations is fed through a pressure reducing stage and is then stored or taken directly to other process units as raw material for the manufacture of nitric acid, ammonium nitrate and urea.

Nitric Acid

The nitric acid unit at Lima employs an adaptation of the Du Pont process operating at approximately 100 lbs. per square inch and has a daily capacity of 180 tons (100% HNO_3) at 58-62% acid strength.

Air is supplied by a centrifugal compressor driven jointly by an electric motor and an expander turbine, the latter utilizing energy in the reheated tail gas discharged from the acid absorption tower at a pressure of 100 lbs. per square inch. Drawn into the compressor through a washer and a filter, the air is discharged at 120 lbs. per square inch. It is then further filtered and heated to the temperature required for combustion with ammonia.

Liquid ammonia is vapourised and then mixed with the heated air stream. Superheated ammonia bearing tail gas from the urea plant can be used to augment or replace the flow of pure ammonia. The mixture of air and ammonia is fed to a converter where it is burnt in the presence of a platinum-rhodium catalyst. The resulting nitric oxide and nitrogen bearing steam leaves the converter and is cooled by heat exchange with the tail gas stream to the expander turbine and then with the process air stream. Further cooling is carried out by passing the converted gas stream through a waste heat recovery boiler in which saturated steam is generated at a pressure of 185 lbs. per square inch. On leaving the waste heat boiler the gas stream passes through a glass wool filter to collect the finely divided platinum which has been mechanically displaced from the platinum catalyst. The filtered gases are then cooled to the desired temperature in a cascade cooler where the conversion of nitrogen oxide to nitrogen dioxide also takes place. A small amount of weak acid condensed in this cooler is delivered to the side of the absorption column at a point where the strength of the acid inside the tower most nearly corresponds to the strength of the condensate. The uncondensed gases, primarily nitrogen, nitrogen dioxide and oxygen, enter the base of the bubble-plate absorption tower and flow upward, counter-current to water (steam condensate) which is used as an absorbing medium. The acid in the column is bleached by a stream of hot air and then delivered to storage by the pressure in the column itself. The overhead or tail gas stream from the absorption tower, consisting primarily of nitrogen is then passed through a cyclonic-type separator to remove any entrained moisture. It then passes to the tail gas reheater and thence to the expander turbine.

The Ammonium Nitrate Plant

Approximately 80% of the ammonia required for the neutralization of nitric acid in

Table I. Nitrogen Solutions produced at Lima

Composition by Weight									
Total Nitrogen	%N	41.0	49.0	41.0	44.0	45.4	21.0	32.0	24.1	
Ammonia	%	26.3	34.0	19.0	28.0	36.8	4.3	—	29.4	
Ammonium Nitrate	%	55.5	60.0	58.0	40.0	—	—	44.3	—	
Urea	%	—	—	11.0	15.0	32.5	37.5	35.4	—	
Water	%	18.2	6.0	12.0	17.0	30.7	58.2	20.3	70.6	
Nitrogen Content by Weight									
Combined Nitrogen (Ammonia	%N	9.71	10.50	10.15	7.00	—	—	7.75	—	
Combined Nitrogen (Nitrate	%N	9.71	10.50	10.15	7.00	—	—	7.75	—	
Combined Nitrogen (Urea	%N	—	—	5.12	7.00	15.16	17.49	16.50	—	
Free Ammonia	%N	21.63	28.0	15.62	23.03	30.27	3.53	—	24.17	
Combined N ÷ Free Ammonia N		0.90	0.75	1.63	0.91	0.50	4.95	—	—	
Physical Properties										
Specific Gravity @ 60°F		1.079	1.042	1.162	1.058	0.928	1.085	1.327	0.897	0.618
Pounds per Gallon @ 60°F ..		9.00	8.69	9.69	8.82	7.74	9.05	11.06	7.48	5.15
Pounds N per Gallon @ 60°F ..		3.69	4.25	3.98	3.88	3.52	1.90	3.54	1.84	4.22
Gauge Vapour Pressure @ 104°F		17	48	10	26	57	0	—	10	211
Salting out Temperature —°F ..		25	−52	+7	−1	+16	+33	+32	−110	−108

the manufacture of ammonium nitrate at Lima is found in tail gas from the ammonia and urea plants, the balance being pure anhydrous ammonia.

The ammonium nitrate solution formed in the neutralizer is concentrated to about 83% strength by the heat of the reaction itself. The steam evaporated from the neutralizer vapourizes incoming liquid ammonia and then passes to a direct contact scrubber where it is condensed by cooling water, the condensate and cooling water flowing to the waste sewer.

The 83% ammonium nitrate solution overflows from the neutralizer to an adjusting tank in which liquid ammonia is added to change it from an acid to a slightly alkaline condition. The product then passes to a run-down tank and is pumped to storage.

Ammonia/Ammonium Nitrate Solutions

Among the principal end-products of the Lima plant, ammonia/ammonium nitrate solutions are prepared by metering liquid anhydrous ammonia, 83% ammonium nitrate solution and water, into a baffle plate mixer. The resulting heat of the solution, liable to cause an excessive rise in vapour pressure, is removed by a continuous recirculation of the mixer effluent stream through a shell and tube cooler. The release of the ammonia/ammonium nitrate solution to storage is controlled by pressure in the circulating system.

In addition to solutions shown in Table I, solutions containing urea are also produced using an 86% urea-water solution in the mixing operation.

The proportion of the ammonium nitrate and urea produced at Lima which is used in the preparation of solution is, of course, varied to suit market requirements.

Urea

The urea plant at Lima employs the partial recycle arrangement of the Inventa process and has a capacity of 120 tons a day. The synthesis of liquid ammonia and gaseous carbon dioxide to urea is carried out at a temperature of 355°F and a pressure of 2,800 lbs. per square inch. Tail gas from the desorbers, which contain ammonia, are sent to the nitric acid and ammonium nitrate plants for ammonia recovery. When these plants are not working and are unable to handle all the tail gas, separate recovery facilities adjacent to the urea plant can be brought into operation. These facilities consist of an absorber for removing carbon dioxide from the gases and a stripper to extract the carbon dioxide from the absorbant to prepare the latter for re-use.

The Lima Complex

One new and important use for ammonia produced at Lima will be in the new acrylonitrile plant owned and operated by the Sohio Chemical Company and due to come into operation in the first quarter of 1960. This will be the first plant to use propylene as a raw material in conjunction with ammonia in acrylonitrile manufacture. Acetonitrile will be obtained as a by-product.

The nitrogen facilities at Lima form an integral part of a petrochemical complex in which production costs are minimised by a high degree of interdependence between the different process units. A growing proportion of the world's nitrogen capacity is likely to follow this pattern, particularly in highly developed industrial areas where there are substantial markets for chemical products and where prices are becoming increasingly competitive.

THE DEVELOPMENT OF THE MODERN AMMONIA OXIDATION PROCESS

By the end of World War I the manufacture of nitric acid by ammonia oxidation over a platinum catalyst was a technically established process. The rapid increase in production of synthetic ammonia enabled this method to become the principal source of industrial nitric acid, and further development of the process in terms both of technical progress and in the size of unit plant has been determined by economic factors.

DURING THE past 40 years the ammonia oxidation process has been the only process of economic importance for the production of nitric acid. During this period as the demand for nitric acid has increased there has been progressive development of the process both technically and in the size of unit plants.

Nitric acid is required by industry in two forms; either as "weak nitric acid" of 50 to 60% HNO_3 or as "concentrated nitric acid" of 95% HNO_3 or greater. The ammonia oxidation process as originally developed produced weak acid, which was often nearer 40 than 50% HNO_3. This acid is quite satisfactory for the production of inorganic nitrates but for organic nitrations the explosives and dyestuffs industries needed concentrated acid. The weak acid is concentrated by distillation with a water carrier, such as sulphuric acid, which must subsequently be reconcentrated. In the 1920s a large proportion of the total acid was required in the concentrated form. This proportion has slowly decreased and the present popularity of fertilizers containing nitrate nitrogen means that most of the nitric acid is required in the dilute form.

Because of the high costs of concentration early attempts to improve the ammonia oxidation process were aimed at making more concentrated acid and, if possible, really concentrated acid.

Effect of Pressure

The reactions involved in the manufacture of nitric acid from ammonia may be summarised as::—

$$4NH_3+5O_2=4NO+6H_2O+216.7 \text{ kilocal} \quad (1)$$

$$2NO+O_2=2NO_2+26.9 \text{ kilocal} \quad (2)$$

$$3NO_2+H_2O \rightleftharpoons 2HNO_3+NO+32.5 \text{ kilocal} \quad (3)$$

As indicated the absorption reaction is reversible and a state of equilibrium can exist between the gas and liquid compositions. This can be expressed as:—

$$\frac{(P_{NO_2})^3(P_{H_2O})}{(P_{HNO_3})^2(P_{NO})}=\text{constant} \quad (4)$$

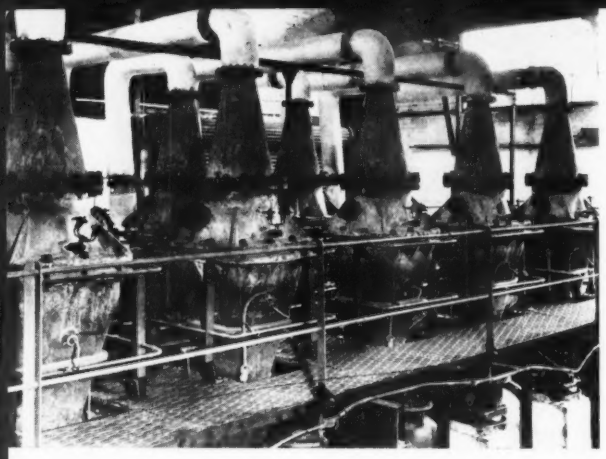
Absorption proceeds at a rate which is related to the extent to which the system departs from equilibrium. Consideration of equation (4) shows that two of the factors relate to the gas composition and two to the acid composition. To obtain a high strength acid the ratio $(P_{NO_2})^3 : P_{NO}$ must be high. This can be achieved by increasing the proportion of the total nitrous gas present as NO_2 (high state of oxidation) or by increasing the total pressure. There is in fact much greater scope for gain by increase of pressure and most of the development work for high strength acid was along this line.

The vapour pressure of nitric acid is such that it is not difficult to obtain about 60% HNO_3 by increasing the working pressure of the absorption system. To get significantly above 60% HNO_3, however, very large and uneconomic increases in pressure are necessary.

A second very important effect of increased pressure is a marked reduction of the volume required for the absorption system. This more than offsets the other effects of increased pressure so that a high pressure plant has a lower capital cost than a low pressure plant.

Early Lines of Development

Plants were produced by E.I. du Pont de Nemours and Co. working at eight atmospheres absolute and by G. Fauser working at five atmospheres absolute. The plants differed in



The original atmospheric pressure ammonia oxidation converters installed at Billingham in the 1920's, employing twenty-inch diameter platinum gauzes with downward flow.

that the du Pont plant oxidised the ammonia under pressure while the Fauser plant carried out this stage at atmospheric pressure. These plants produced acid of about 60% HNO_3 compared to the 40 to 50% of earlier plants.

A different approach was used by the Bamag Company of Berlin which oxidised the ammonia with liquid oxygen, thus obtaining a very concentrated nitrous gas. By the use of refrigeration a large proportion of the nitrous gas was recovered as liquid N_2O_4. This was reacted in autoclaves under pressure with oxygen and dilute nitric acid to form 98% HNO_3.

Most Economic Pressure

As the emphasis has swung more to low cost weak nitric acid with relatively small premiums for acid concentration, the attraction of the high pressure plants has declined because of their high operating costs. The most economically attractive working pressure is currently about three atmospheres absolute and development is concentrated on the efficient utilisation of the substantial heat of reaction. There remains the basic question exemplified by the two original pressure plant designs, whether or not to pressurise the ammonia oxidation step of the process.

Ammonia Oxidation

The all-important first step in the conversion of ammonia to nitric acid is the oxidation of the ammonia to nitric oxide over a catalyst as set out above as reaction (1). The normal working temperature of the platinum or platinum alloy catalyst is 800 to 900°C and the temperature rise due to reaction with the ammonia concentrations normally employed ranges from 600 to 700°C. It is therefore necessary to heat the gases before they reach the catalyst and this involves the risk of thermal decomposition of ammonia:—

$$2NH_3 = N_2 + 3H_2 - 21.9 \text{ kilocal} \qquad (5)$$

The homogenous rate of decomposition is negligible under normal nitric acid plant conditions. However, the reaction is catalysed by many materials particularly when an oxide film is present.

Ammonia is oxidised to NO on the platinum catalyst with remarkable facility and it appears that every ammonia molecule which strikes the catalyst is oxidised. The catalyst can, however, be loaded to the point where ammonia breaks through and this will then react in the gas phase with the nitric oxide:—

$$4NH_3 + 6NO = 5N_2 + 6H_2O + 432 \text{ kilocal} \qquad (6)$$

If on the other hand the catalyst is very lightly loaded the nitric oxide may be decomposed by the catalyst:—

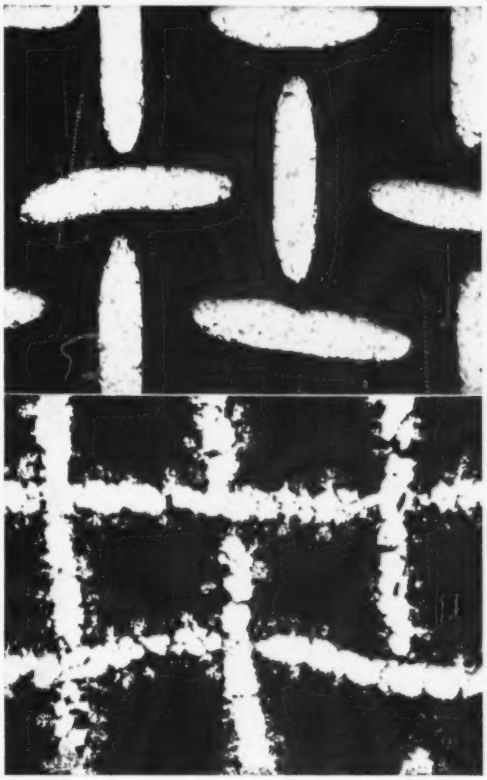
$$2NO = N_2 + O_2 + 21.5 \text{ kilocal} \qquad (7)$$

Since both high loading and low loading reduce conversion efficiency the optimum loading range has to be established. In practice it has been found that the limits of optimum loading are broad and that over an appreciable range of loadings the conversion is constant. The optimum loading is affected by many factors, of which catalyst temperature and gas pressure have the most striking effect. Optimum loading conditions, when both catalyst temperature and gas pressure are increased, improves the chances of an ammonia molecule colliding with the catalyst.

Catalyst Performance

In view of the high cost of the platinum metals used, it is economically desirable to reduce the amount of catalyst employed. This may be done by increasing the throughput and raising the working temperature to maintain the efficiency of conversion of ammonia to nitric oxide. However, the catalyst deteriorates in service and some of the metal is lost from the wire gauzes, which eventually become so weak that they have to be removed and the metal recovered. The rates of deterioration and of loss of metal increase very rapidly with

temperature and with pressure and make it unattractive to push up the loading and hence the working temperature. When the oxidation



Photomicrographs (x 100) of catalyst gauzes. Top, a fairly new catalyst; bottom, a well-used catalyst.

of ammonia is carried out under pressure the size restriction of the catalyst chamber and the general effects of pressure favour high catalyst loading and high catalyst temperature. With the original platinum catalyst these conditions would have involved unacceptable losses of metal and they were made possible only by the development of an alloy which suffered much reduced loss of metal. This alloy—a 10% rhodium platinum compound was chosen from many possibilities by Handforth and Tilley, of du Pont de Nemours and Co., in the United States of America, who published their results in 1934 in " Industrial and Engineering Chemistry." Because of its better efficiency, reduced rate of loss and longer life, this alloy is now the standard ammonia oxidation catalyst and is used universally in the form of gauze. The gauze is normally of 80 mesh, the wire being about 0.0003 inch diameter.

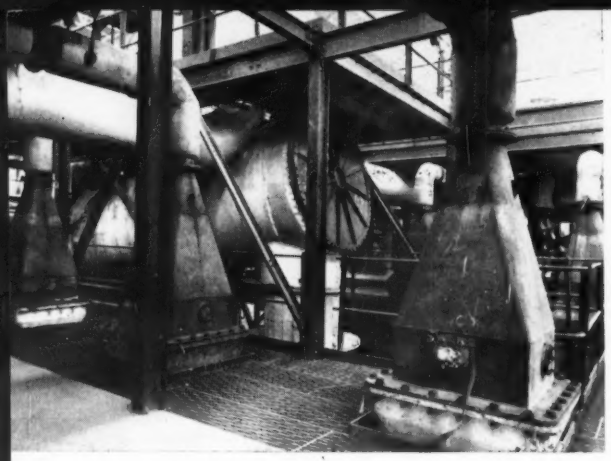
The mechanism by which the catalyst is "lost" is not known. It is a matter of observation that during service the smooth wires of the catalyst develop excrescences and recrystallisation proceeds until the "wire" is a chain of crystals with extremely poor mechanical properties. The excrescences become detached in operation and may be recovered by suitable filters installed after the catalyst.

Recovery of Catalyst Metal

A process for recovering the metal lost from the catalyst was developed in Germany during the war. The hot gases were passed through a bed of gold-plated ceramic rings and the platinum alloyed with the gold. The coating was subsequently stripped and refined. More recently fibrous filters have been developed in the United States to filter out the particles of platinum from the hot gas stream. Because of the pressure drop introduced into the plant these filters have not been universally adopted.

Converter Design

The temperature rise across the catalyst depends primarily on the concentration of ammonia in the gas. Since the temperature for optimum conversion is determined by the loading of the catalyst, this, in conjunction with the concentration of ammonia in the gas to be converted, fixes the temperature to which the gas must be preheated before it reaches the catalyst; thus if the ammonia concentration is low then the preheat temperature will be high. In high pressure converters the ammonia concentration in the gas mixture must be kept below the strength at which combustion can occur. This requires high preheat temperatures to obtain the high catalyst temperatures necessary for the high loading. This is in itself an adverse feature since the relatively high surface/volume ratio of high pressure plant favours the cracking of ammonia. The use of suitable materials such as stainless steel, however, enables reasonable efficiencies to be achieved in practice though the efficiency is commonly lower than in low pressure plants whereas the catalyst loss is higher.



Medium pressure ammonia oxidation converter of the late 1940's with square gauzes.

Since the catalyst operates at a temperature of 800 to 900°C the rhodium-platinum wire gauze has relatively little mechanical strength and must be supported so that it can sustain the pressure difference due to the flow of gas through the gauze. The problem of supporting the catalyst was solved by two different means. In England a small gauze was clamped in a joint with limited support against downward flow. On the Continent a very large gauze was floated on a rising stream of gas. As heat and oxidation resistant materials were developed, it became possible to support larger areas of gauze against downward flow and the unit size of gauze in this type of converter increased because from the viewpoint of cracking ammonia and thermal efficiency fewer plants and each occupying less space are advantageous. Present-day designs not only enable gauzes of large diameter to be used with adequate supports but they also permit large converters to be made pressure tight so that the need for atmospheric pressure oxidation of ammonia has been removed.

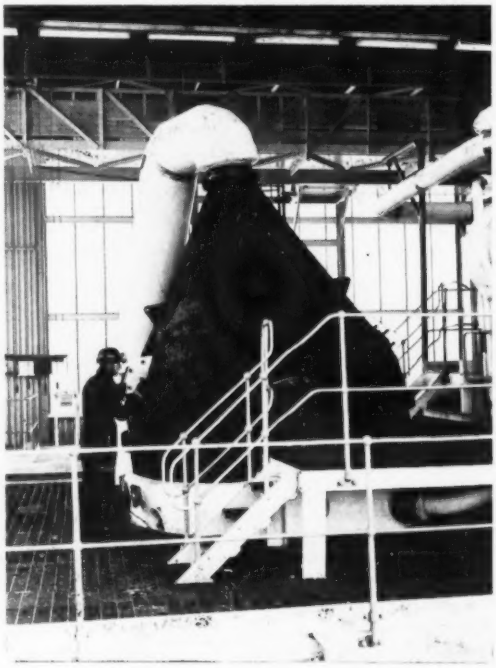
Gas Purity

Owing to the high working temperature the catalyst is not very susceptible to poisoning and this combined with the high purity of ammonia produced in synthesis plants gives a complete immunity to trouble from this cause. Oxides of iron have, however, a deleterious effect on performance as they catalyse the cracking reaction (5); non-volatile non-combustible dust has also an adverse effect as it tends to blanket the catalyst. The gases must therefore be freed from all dust and scale by filtration before passing to the catalyst. Many types of filter have been used including porous stoneware but the type appears unimportant so long as the dusts normally present in the gases are effectively removed.

Some dust inevitably passes any filter and the catalyst performance deteriorates in time. It is common practice to clean the catalyst periodically by treatment with hot dilute hydrochloric acid. The frequency at which this is done is a matter of economics for the used catalyst gauze is brittle and is easily damaged by handling.

Heat Economy

Reactions (1), (2) and (3) show that 60% of the heat evolved in nitric acid manufacture arises in the oxidation of ammonia to nitric oxide. This heat is available as sensible heat in the gases leaving the catalyst and at a sufficiently high temperature to make recovery worthwhile. Some of the sensible heat in the



An ammonia oxidation unit in a modern nitric acid plant employing large circular rhodium-platinum gauze nets for medium pressure conversion.

converted gas is used for preheating the gases going to the catalyst but the heat of reaction is available for other purposes. Initially this heat was recovered as steam in waste heat boilers. By the use of economisers the heat recovery can be made effective to about 82% of the heat of oxidation of ammonia but cannot be taken further because of the dew-point of the converted gases.

When plants are operated under pressure it is possible to recover the heat of reaction as mechanical energy by heating the exhaust gases and using them to drive a turbine. Because of the characteristics of heat engines the amount of energy which can be usefully recovered in this way is limited. For the relatively low pressure plants which are now favoured the greater part of the heat available is recovered as steam and a small part is recovered as mechanical energy at a very high conversion efficiency.

The oxidation of nitric oxide to nitrogen dioxide is responsible for about 15% of the total heat evolved when converting ammonia to nitric acid. This heat is usually evolved at low temperature and lost to cooling water because of the negative temperature coefficient of the reaction velocity constant. However, when the process is operated at higher pressure it becomes practicable to raise the working temperature to the point where this heat can be usefully recovered. At the present time this would appear to represent the limit to which the energy of reaction can be recovered.

We are indebted to Johnson, Matthey and Co., Limited, for placing this article, written by A. W. Holmes, B.A., B.Sc., at our disposal.

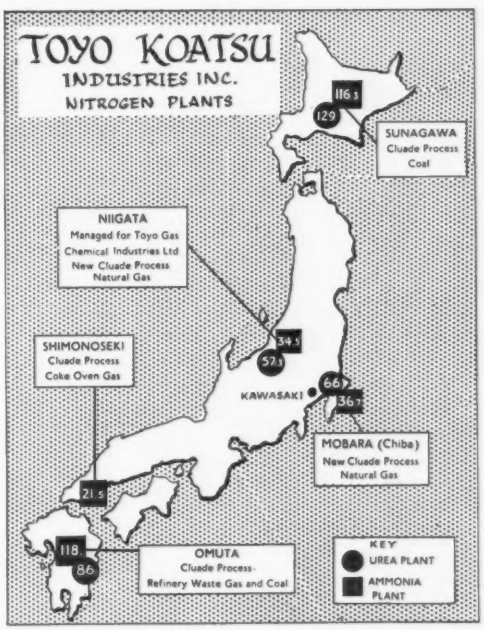
THE TOYO KOATSU UREA PROCESS

THE LARGEST NITROGEN PRODUCER IN JAPAN, Toyo Koatsu Industries Inc., was founded in 1933 as an ammonium sulphate manufacturer. Ammonia was produced by the Claude process from coal and coke. Today five synthesis plants are in operation with a combined ammonia capacity of 329,000 tonnes a year and production in 1958 totalled 250,187 tonnes.

In addition to ammonia, ammonium sulphate and urea, Toyo Koatsu Industries produce calcium superphosphate and a wide range of industrial chemicals including methanol, formaldehyde and acrylonitrile. It is upon urea production, however, that the greatest emphasis is placed.

The Toyo Koatsu Process

Urea manufacture is carried out at the Hokkaido works at Sunagawa, at Omuta, at the Chiba works at Mobara and at Niigata. Production, which started on a commercial basis in 1948, totalled 188,000 tonnes in 1958. A process developed by Toyo Koatsu Industries is employed at all four plants and is also used at the Kawasaki plant of Showa Denko K.K. As yet this process is not in use outside Japan. Nevertheless, the combined capacity of the five Toyo Koatsu type plants now in operation amounts to 418,000 tonnes a year equal to 16% of the total world capacity.



Capacities of ammonia plants are shown in thousand tonnes anhydrous ammonia and urea plants in thousand tonnes product.

Development

Research on urea synthesis in Japan was started by the Claude-Nitrogen Industry Co., the predecessor of Toyo Koatsu Industries Inc., as early as 1926. Pilot plant production began in 1937 and the first commercial plant was completed in 1948 at Sunagawa in Hokkaido. This plant employed a "once-through" arrangement of the Toyo Koatsu process, but a "partial recycle" system was introduced in 1950 at the Omuta plant, recovering excess ammonia. In 1954 a partial recycle system involving gas separation was incorporated at the Sunagawa plant but construction and operating costs proved unsatisfactory and continuing research resulted in the development of a total recycle system. This new arrangement, incorporating solution recycle was adopted at the Chiba plant commissioned in 1958. Solution recycle is also used in a partial recovery arrangement of the Toyo Koatsu process employed in the Toyo Gas Chemical Company's works at Niigata, commissioned two months earlier that year.

Following the successful operation of the Chiba plant, an improved version of the total solution recycle system has been developed and will be incorporated in extensions to be carried out at Chiba in 1960.

Once-Through System

The original and basic arrangement of the Toyo Koatsu process, the "once-through" system incorporates the use of excess ammonia with operating conditions in the reactor maintained at a pressure of 3,700 to 3,850 lbs. per square inch and a temperature of 180 to 190°C. The conversion rate of carbon dioxide to urea is approximately 71%, that of ammonia being about 32%.

The liquor from the reactor consisting of urea, water and unconverted ammonium carbamate is fed to a decomposer where the unconverted ammonia and carbon dioxide are removed from the solution.

Partial Recycle

Two partial recycle systems have been developed for the Toyo Koatsu process. One, in use at Omuta and at the Kawasaki works of Showa Denko K.K., involves the recovery of excess ammonia after separation from the reactor product and is carried out at a pressure of 170 to 214lbs. per square inch. The recovered ammonia of high purity and with no carbon dioxide content, is liquified in a condenser and returned to the reactor. Between 67 and 76% of the excess ammonia is recovered with this system, raising the overall rate of ammonia conversion to 51 to 56%.

The other partial recycle system is in use at the Toyo Gas Chemicals' plant at Niigata and effects the recovery of both ammonia and carbon dioxide. Liquor from the reactor is decomposed in two stages under high pressure and is then concentrated. Gas from these decomposers is sent to an absorber from which pure ammonia is recovered and recycled to the reactor together with ammonium carbonate solution discharged from the bottom of the absorber. Effluent gas from a third, low pressure decomposer is available as a by-product for use in the manufacture of ammonium sulphate or ammonium nitrate.

Total Gaseous Recycle

At present in operation at the Chiba plant, the total recycle in gaseous phase arrangement of the Toyo Koatsu process involves the recovery of gas from three decomposers, one working at high pressure, one at medium and one at low pressure. The gases from these decomposers are taken to an absorber from which concentrated ammonium carbonate solution is recycled to the reactor. At the same time excess ammonia is recovered, condensed and recycled.

Total Solution Recycle

The latest development of the Toyo Koatsu process, the total solution recycle system, appears to afford higher efficiency and reduced operating costs by comparison with previous arrangements. Operating conditions in the synthesis reactor are maintained at a temperature of 180 to 190°C and a pressure of between 3,130 and 3,270lbs. per sq. inch. The molar ratio of ammonia to carbon dioxide in the synthesis feed is 3.5 to 1, a ratio chosen after extensive investigations of molar ratios in the range of between 3 and 8 to 1. The conversion efficiency of carbon dioxide feed to urea is between 57 and 58%.

The Chiba Works. Left to right, purification plant, prilling tower, urea storage house.

The effluent liquor from the reactor consisting of urea, water, unconverted ammonium carbamate and excess ammonia passes through an expansion valve at the outlet of the reactor and is sent to a high pressure decomposer. Excess ammonia and part of the unconverted ammonium carbamate are decomposed and separated. The liquor is then fed into a low-pressure decomposer where almost all the residual ammonium carbamate is decomposed.

The product of the low pressure decomposer is a urea solution of about 70% concentration containing a small quantity of ammonia and carbon dioxide. These unconverted materials are removed in a gas separator and fed to the recovery section, leaving urea solution which is available for concentration and processing.

Excess ammonia and carbon dioxide separated in the high pressure decomposer are fed to a high pressure absorber where they meet a solution of ammonia, ammonium carbonate and water. The resulting ammonium carbonate solution is sent to the synthesis reactor. Ammonia and carbon dioxide separated in the low pressure decomposer are fed to a low pressure absorber to meet a solution obtained in the gas separator; the resulting solution is fed to the high pressure unit for use as an absorber.

Prilling

Urea solution is concentrated by evaporation to 90% strength and impurities, including metallic particles, are removed by a filter. The solution is then passed through a crystallizer, a centrifuge and a drier. To obtain prilled urea, crystalline urea is taken to the top of a prilling tower, melted and passed down through the tower. As very little urea sticks to the inside walls of the tower, washing equipment is not required. Subsequent coating is also unnecessary as the prills are sufficiently hard.

The End-Product

Prilled urea produced by this system has a low biuret content and is suitable for all fertilizer requirements, the crystalline material being suitable for technical use.

Product Quality

	Prilled Urea	*Crystal Urea*
Biuret %	0.5 (max)	0.15 (max)
Moisture %	0.3	0.3
Free ammonia % ...	0.02	0.002
Iron content % ...	0.0003	0.0003
pH (10% solution) ...	9.0	7.2
Ash %	0.002	0.002
Particle size, m.m. ...	1 - 2.5 (95%)	0.3 - 0.5

Conclusion

The Toyo Koatsu Co. has concentrated its attention on a solution recycle system as steam consumption is lower than with gaseous recycle systems, and it consequently affords lower construction and operating costs. The use of a substantial excess of ammonia and operation at a pressure in the synthesis reactor as high as 230 kg/cm² minimises the corrosion problem, at the same time improving the conversion rate of carbon dioxide. It is in fact possible to obtain a conversion efficiency approaching 100% with the latest solution recycle arrangement with consequent saving in raw materials and utilities.

Consumption per ton of urea

Carbon dioxide	26,800 cubic feet
Ammonia	1,290 lbs.
Steam	3,525 lbs.
Electric power	170 KWH
Cooling water	110 tons

The performance claimed for the latest solution recycle arrangement of the Toyo Koatsu process compares favourably with that of each of the five modern processes now available to urea manufacturers.

UREA-AMMONIUM SULPHATE

A PROCESS for the manufacture of a complex fertilizer containing urea and ammonium sulphate has been developed by the West German firm of Hibernia A.G. An important feature of this process is that it overcomes many problems connected with the conversion of an aqueous solution of urea to a solid fertilizer, as it eliminates the high temperatures required for evaporation which can lead to the decomposition of the urea to biuret.

The addition of ammonium sulphate to urea solution to lower the solidification point of the water-free fused mass and the addition of small quantities of urea to ammonium sulphate to improve its storage properties are already established practices. In the Hibernia process, however, the ammonium sulphate is not admixed to the urea but is an essential constituent of a fertilizer prepared from urea, sulphuric acid and ammonia. Sulphuric acid is added to urea solution, the acid being simultaneously neutralized with ammonia, and the heat generated by the neutralization removes the bulk of the water contained in the reaction mixture.

The Process

Sulphuric acid at 70% strength is added to a 40% solution of urea in a ratio of 7.14 H_2SO_4 to 4.78 NH_2CONH_2. Simultaneously ammonia is introduced in sufficient quantity to manufacture ammonium sulphate and leave an excess of ammonia. During this operation the pressure in the reaction chamber is maintained at 500mm. Hg. The temperature must be held below 140°C, preferably between 80°C and 100°C to prevent decomposition of the urea. At the end of the neutralization step the product, now almost solid, is removed from the reaction chamber and subjected to further drying. The finished fertilizer material contains 26.8% nitrogen.

Several variations of this process are possible. Part of the ammonia required for the preparation of ammonium sulphate can be present in the urea solution at the start of the operation, dissolved as such or in the form of ammonium compounds such as ammonium carbamate. The additional ammonia required can be introduced in anhydrous form or mixed with other gases such as nitrogen or air. The introduction of gas at this stage in stirring up the material considerably improves the speed and effectiveness of the reaction and does much to prevent decomposition of the urea. In some cases, however, a further mechanical stirring may be required.

The conversion can be carried out at reduced or normal pressure. At reduced pressure and at low temperature the need for a large quantity of excess ammonia, whether in conjunction with other gases or not, is eliminated as a vacuum evaporation takes place. The whole operation can be carried out as a batch or as a continuous process. In the continuous method, urea solution, sulphuric acid and ammonia are introduced into the reactor vessel at a rate corresponding to the withdrawal.

The product is a rapidly acting fertilizer, very stable in storage and with good handling qualities. Its manufacture would appear particularly attractive where urea is produced as an aqueous solution requiring extensive evaporation in the course of conversion to a solid fertilizer.

AMMONIATED COAL HUMUS

THE IMPORTANCE of the complex organic bodies known as "soil humus" and the part they play in maintaining the fertility of the soil is widely recognised. Humus improves the physical structure of the soil, provides better aeration by imparting a binding effect on its particles and increases its water retaining and heat absorbing capacity. It also acts as a buffer preventing rapid changes in the acidity or alkalinity of the soil. In addition humus retains the essential plant nutrients, particularly phosphorus and iron, and trace

elements in an available form and is an important source of carbon dioxide for plant growth. Humus promotes the utilization of nitrogen, phosphorus and potash in the soil, while it retains the various nutrients liberated as a result of microbial action and ultimately provides them to plants.

With the object of developing a fertilizer material which will supply both additional nitrogen and humus to the soil, the Central Fuel Research Institute at Jealgora, India, has recently conducted a series of experiments. A synthetic humus was produced by mild oxidation of coal and exhibited properties similar to those occurring in soils. This coal humus easily combines with ammonia forming a product which exhibits the qualities of humus as well as those of a synthetic nitrogen fertilizer, and which at the same time does not have any undesirable residual effect in the soil.

Two different processes have been developed at the Central Fuel Research Institute for the production of nitrogenous coal-humus fertilizers. The first product, designated as "ammonium humate" is prepared by oxidising coals in a fluidized bed in a stream of air at 200°C, followed by treatment with ammoniacal liquor at normal temperature and pressure. The fixed nitrogen content of this material is only about 6 to 9%, whereas if ammoniation is carried out at high temperature and pressure, the nitrogen content can be raised as high as 18%.

The second process involves the simultaneous oxidation and ammoniation of coal in a fluidized bed at 300°C in a mixed stream of air and ammonia. The nitrogen content of the material produced by this process, designated as "nitrogen enriched product," varies between 18% and 22%. This material has similar properties to the pressure treated ammonium humate, its special merit lying in the fact that it can be prepared by a single step and is consequently cheaper to produce.

Nitrification and other laboratory tests carried out with the two fertilizers revealed that the nitrogen in the ammonium humate containing 6 to 9% nitrogen is in quickly available form, whereas that in the pressure treated ammonium humate and nitrogen enriched product is slow acting.

Field Tests

A programme of field tests was undertaken to compare the effectiveness of the nitrogenous coal-humus fertilizers with that of ammonium sulphate and a purely organic fertilizer containing 5.5% N. Each material was applied to rice in strengths of 30lbs. N per acre and 60lbs. N per acre, the experiments being carried out on loam soil. The average yields in grain and straw per acre with the different treatments were as follows:

	lbs. per acre	
	Grain	*Straw*
@ 60lbs. N per acre		
Ammonium sulphate (20.5% N) ...	3,450	14,000
Ammonium humate (5.4% N) ...	2,888	11,070
Organic manure (5.5% N)	2,712	10,630
N enriched product (21.4% N) ...	2,391	9,335
@ 30lbs. N per acre		
Ammonium sulphate (20.5% N) ...	2,562	9,851
Ammonium humate (5.4% N) ...	2,220	8,545
Organic manure (5.5% N)	2,081	9,350
N enriched product (21.4% N) ...	1,927	7,928
No fertilizer	1,655	6,552

A further series of tests were carried out on wheat under similar conditions to those held on paddy except that the plant food dosages were altered from 30lbs. N per acre and 60lbs. N per acre to 20lbs. N and 40lbs. N per acre. The average yields per acre of wheat grain and straw were as follows:

	lbs. per acre	
	Grain	*Straw*
@ 40lbs. N per acre		
Ammonium sulphate (20.5% N) ...	645	1,252
Ammonium humate (5.4% N) ...	556	1,132
Organic manure (5.5% N)	495	900
N enriched product (21.4% N) ...	466	937
@ 20lbs. N per acre		
Ammonium sulphate (20.5% N) ...	427	869
Ammonium humate (5.4% N) ...	368	765
Organic manure (5.5% N)	345	548
N enriched product (21.4% N) ...	345	645
No fertilizer	277	585

The good initial crop response achieved by ammonium humate in these tests and the residual effect of the nitrogen enriched product coupled with their beneficial influence on the quality of the soil should recommend these fertilizers for use in many parts of the world. Coal dust, slacks and other colliery and washery rejects together with coke-oven and gas works liquor could be used to good effect to produce a cheap and effective nitrogen fertilizer with additional properties to those of wholly inorganic materials.

plant and equipment

THE NITROMETER

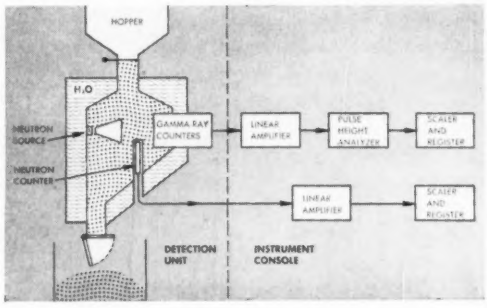
THE NITROMETER, a gamma ray spectometer for measuring the nitrogen content in solids, recently developed by the Schlumberger Well Surveying Corporation of Ridgefield, Connecticut, may have important applications in the control of food processing and in the manufacture of fertilizers and explosives. Analysis carried out with the Nitrometer is non-destructive and the accuracy is said to compare favourably with the well-established Kjeldahl method which, however, takes four hours compared to 15 minutes by the new method.

The Demonstration Unit

Tests have been carried out on a demonstration unit. This consists of an instrument console containing the various electronic components and a detection unit comprising a test chamber, neutron source, scintillation counters and a neutron monitor.

A solid sample of about half a cubic foot is poured into the test chamber where it is bombarded by fast neutrons. Hydrogen in the sample and in the shielding slows down the neutrons, converting them to thermal energy neutrons. These can then be captured by elements in the sample which in turn emit gamma rays, mainly the 2.23 m.e.v. hydrogen live with spectra for other elements present.

The nitrogen spectrum arises when a thermal neutron is captured by a N 14 nucleus creating a N 15 nucleus. This immediately decays to a lower energy state, emitting a gamma ray of 10.8 m.e.v. Scintillation counters detect the gamma rays, the pulses from these counters being amplified, analysed and recorded on a register. The strength of the neutron source is simultaneously monitored by



a special counter which records the pulse. The nitrogen content is computed by dividing the counts from the gamma register by the number of counts on the neutron register multiplied by the sample weight.

The demonstration unit, intended originally for use on any free flowing solid, is also claimed to be suitable for use with liquids. Although designed for materials with a nitrogen content of between 3 and 6% it can be adjusted to work on higher or lower ranges. The Nitrometer can be adapted for semi-continuous operation for the control of such operations as blending, mixing and extraction.

THE NEUMO PUMP

Introduction

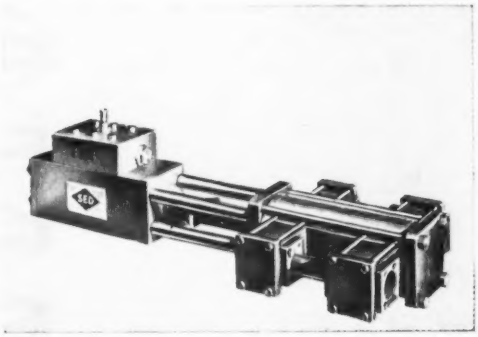
For many years designers in the pneumatic field have been endeavouring to perfect the simplest possible piston-type motor. Such a motor was envisaged as having a reciprocating piston controlled in its stroke by a reciprocating piston valve which in its turn would be controlled by the piston. Although this would seem the ultimate in simplicity, a seemingly insurmountable barrier has prevented such a motor functioning satisfactorily. So that a change of direction in the case of both piston

and valve might be brought about, air pressure must be alternated from one end of the component to the other, which results in a rising pressure at one end, passing at some point a falling pressure at the other. Naturally, if there were insufficient momentum present at such a point the component would stall and remain locked.

In the " Neumo " motor this dead position has been completely avoided and, no matter the position in which the valve or piston comes to rest, the motor will in all cases function normally immediately air is supplied. Great reliability and long life can thus be expected from a motor of such simplicity and in fact tests over the last five years have failed to show any appreciable wear of either component or the main motor block.

Construction

The body of the pump is divided into three or five main parts—the pump body and two valve chests in the use of small pumps or four in the case of larger pumps. The smaller pumps have two valves mounted in each chest, whilst in the larger versions each valve has its own chest. The valves are of spring-loaded disc type and the whole inlet valve assembly is similarly spring-loaded on to another seat to



The Neumo Mark X pump unit.

provide overload facilities. Valve springs are trapped within a cavity when the disc is on its seat, thus obviating to a great extent moving material wearing the spring. The adjustable steel connecting rod to the plunger, which may be in the form of either double cups or a ring carrier with spring-loaded rings, passes through a gland housing containing a multi-chevron gland of varying materials.

Availability and Capability

Neumo Pumps can be applied in a wide range of materials to meet individual requirements and as the bore size of the pump can be varied in relation to the bore size of the motor it is possible to supply pumps for any one purpose. Pumps in the smaller Mark IV range with maximum capacities of 120 gallons per hour can be supplied in cast iron, brass and stainless steel, whilst plastic versions of Fluon, high density polythene and rigid P.V.C. are available with a maximum delivery of 60 gallons per hour.

The Mark X range with capacities of 1,500 gallons per hour includes cast iron, brass, stainless steel, Tufnol and rigid P.V.C. versions. Here again the plastic models would be reduced in maximum delivery. The latest addition to the range, the rigid P.V.C. model is of particular interest as the following materials can be handled at the temperatures shown.

Up to 60° C	*Up to 20° C*
Nitric Acid (up to 80%)	
Urea (up to 30%)	Ammonia (100% Liquid)
Ammonia (Dry Gas)	

Operation

The air operation of these pumps is very advantageous where their use in flame-proof areas is required, as the necessity for motors and switchgear normally needed in such areas is avoided, thus greatly reducing the initial costs. The use of Fluon and the latest elastomers ensure the lowest possible friction and ensure that there is no metal to metal sliding contact in the pump. Further, the use of such equipment obviates periodic inspection and reduces insurance premiums. Figures obtained over years of use on cost/service basis have proved to be extremely favourable. Replacement of motor parts is almost unknown and apart from the occasional renewal of gland packings and isolated instances of ill use these pumps have proved equally trouble free.

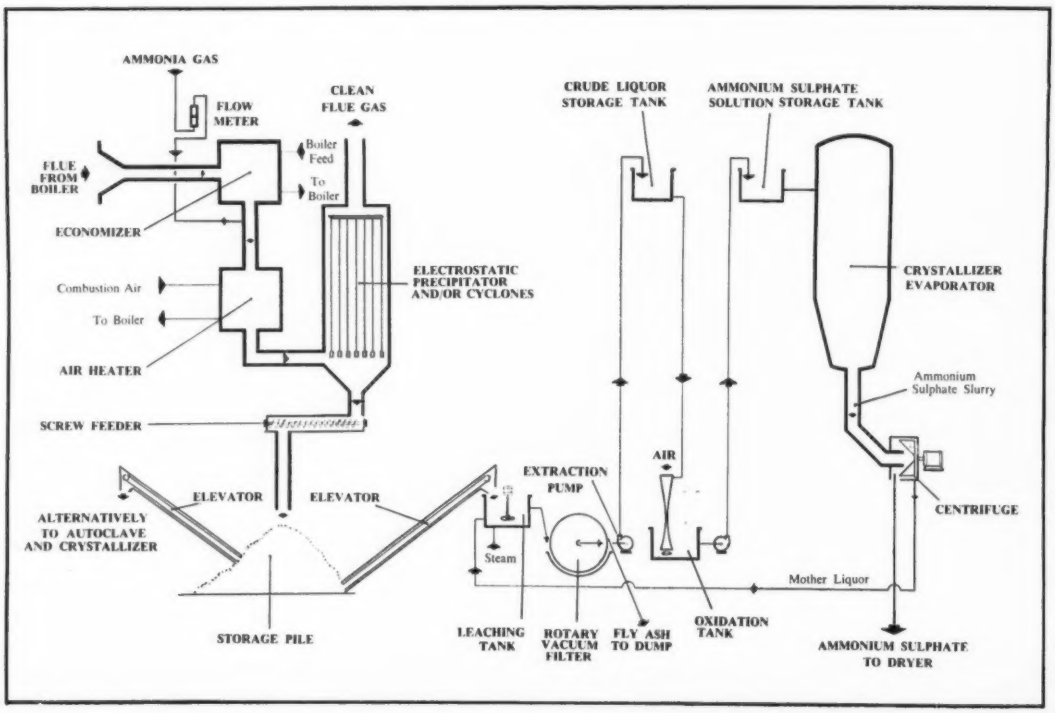
SULPHATE REMOVAL FROM FLUE GAS

A patent has recently been taken out by Chemical Construction (G.B.) Ltd. covering their process for the removal of sulphur present in flue gas and the recovery of ammonium sulphur salts for use in the manufacture of sulphate fertilizer. The application of this development in power stations and steelworks could have very far-reaching effects on the nitrogen industry and pattern of fertilizer supplies throughout the world.

In this process gaseous ammonia is injected into the flue gases between the economiser and the air heater. The gas temperature is not lowered and wet scrubbing is not used. The ammonia reacts with the sulphur oxides produced by combustion of the sulphur contained in the fuel. Solid salts of ammonium sulphite, bisulphite, sulphate and thiosulphate are obtained and can be removed as a powder from the gas stream in the high voltage electrostatic precipitators installed in most large power stations. The residue extracted by this process is a mixture of ammonium sulphur salts and fly ash. The ammonium sulphur salts can be separated from the fly ash and used in the manufacture of ammonium sulphate.

Tests have already been successfully carried out on flue gas at a volume of 100,000 cubic metres an hour and further tests on an even larger scale are planned. 90% of the total sulphur content of the gas can be neutralized with no ammonia loss.

This process, installed at what is believed will be a negligible capital outlay, should make it possible to produce ammonium sulphate at an appreciably lower cost than is at present possible with processes employing sulphuric acid or gypsum. It would also play a major part in reducing the considerable quantity of sulphur discharged to the atmosphere at power stations and steelworks.



current events

UNITED KINGDOM

Express Rail Deliveries of Fertilizer

Deliveries of fertilizer by rail in the United Kingdom have been speeded up by a new system which has been brought into operation this year. The two largest nitrogen fertilizer works, those of Imperial Chemical Industries Ltd. at Billingham and Fisons Ltd. at Stanford-le-Hope, are now served by express freight trains working at speeds of over 50 m.p.h.

Under the old system wagons were taken from Billingham to a local marshalling yard and there added to trains bound for their particular destination. In many cases these wagons would have to be sorted again in marshalling yards, reaching their destinations two or even three days after despatch. Under the new system all freight wagons used are fitted with vacuum brakes to permit high speed running and complete trains, each for a pre-arranged district, are made up on the factory grid. As a result train loads of 300 tons are reaching the South and West of England within 24 hours of leaving Billingham. With pre-arranged schedules it is possible to advise agents of arrival times so that unloading can be planned in advance and consumers advised when to expect delivery. On some days in the spring "peak" delivery period as many as eight special trains left Billingham in a day.

Express Fertilizer Deliveries. Top, "Fisons Special." Ammonium Nitrate en route from Stanford-le-Hope to the company's works at Immingham; bottom, I.C.I., the marshalling grid at Billingham.

To deliver hot 86% ammonium nitrate solution from the Stanford-le-Hope plant to Fisons' compounding works, British Railways employ 45 tankers, each with a capacity of 3,300 gallons and designed for a maximum speed of 70 m.p.h. Each train consists of 15 tankers and can be loaded in four to five hours. A special tanker to take liquid ammonia can be attached to the train as required.

The ammonium nitrate solution is transported at 120°C providing an ample margin over the freezing point of the solution at 85°C. The tank cars are, however, provided with steam coils to cover unforeseen delays on the journey.

CANADA

More Nitric Acid at Welland

Cyanamid of Canada Ltd. have awarded a contract to Arthur G. McKee & Co. of Canada Ltd., of Toronto for the design and construction of additional nitric acid facilities at their Welland, Ontario works. The process employed will be based on that developed by Friedrich Uhde G.m.b.H. of Dortmund. With a capacity of 190 tons per day the new unit, due to come into operation in the spring of 1960, will be the largest in Canada.

The bulk of the nitric acid produced at Welland is used in the manufacture of some 60,000 tons of ammonium nitrate a year. The ammonia installations at these works are at present being rebuilt in a $5 million programme which, by the summer of 1960, will convert operations from the use of coal to natural gas.

Inventa Process for Cominco Plant

The urea plant to be built for the Consolidated Mining & Smelting Co. Ltd. at Turner Side near Calgary will employ the Inventa process. Involving a capital outlay of $5 million, the new unit will have an annual capacity of 36,000 tons and will be completed by the summer of 1960. The Turner Side works on the Bow River have an annual capacity of 85,000 tonnes N based on the use of natural gas from Turner Valley. Part of the ammonia produced is used in the manufacture of nitric acid and ammonium nitrate in the same works, the balance at present being supplied to Cominco's works at Trail and Kimberley, B.C. for use in the manufacture of ammonium sulphate, ammonium nitrate and ammonium phosphates. It is probable that a "once-through" or partial recycle arrangement of the Inventa process will be used in the new plant at Turner Side with unconverted ammonia being used in the ammonium nitrate plant.

When in operation, the new plant at Turner Side will raise Canada's urea capacity to 102,000 tons a year. The first urea plant in Canada was commissioned in the spring of this year by Cyanamid of Canada Ltd., at Hamilton, Ontario based on coke-oven gas from adjacent steel mills of Dominion Foundries and Steel Ltd. The bulk of the urea produced in Canada is destined for export, chiefly to the United States.

INDIA

New Products from Sindri

The manufacture of urea and ammonium sulphate nitrate has started at the Sindri works in Bihar State. The first major nitrogen plant to be commissioned in India, the Sindri works came into operation in 1956 with an annual capacity of 70,000 tonnes N based on the use of coke-oven gas. Hitherto ammonium sulphate —produced by direct reaction of gypsum, carbon dioxide and ammonia—was the only fertilizer manufactured at an annual rate of 330,000 tonnes. Now that the ammonia capacity has been raised to 117,000 tonnes N a year and new equipment installed for the manufacture of nitric acid and ammonium nitrate, production will consist of up to 70,000 tonnes of urea and 400,000 tonnes of ammonium sulphate nitrate.

UNITED STATES

Ammonium Nitrate for Ski Resorts

It has been reported from Kansas City that ammonium nitrate spread on sun-softened snow absorbs much of the moisture and produces a hard granular surface within 15 minutes. Canadian resorts have also used ammonium nitrate and believe that it may make it possible to prolong the skiing season by two or three weeks.

Many enthusiasts prefer spring skiing as there is more sunshine. The snow at this time of year tends to melt by midday and become like butter, freezing again in the late afternoon producing an icy and difficult surface. Ammonium nitrate could be used on selected runs to obtain a fast, dry and much safer surface throughout the day and would be a worthwhile investment for ski resorts as its reward would be a valuable extension to their season. It would also encourage grass growth for a better snow holding surface for the following season.

Nitrogen for the Missile Industry

Satisfactory operation is reported from the new $600,000 nitrogen and oxygen plant commissioned early in 1959 at Denver, Colorado by the Air Reduction Sales Co. The company's decision to build a plant in this area was based on the rapid and continuing growth of industry in the Rocky Mountain region affording a range of applications for high purity nitrogen and oxygen. These include metal working and the construction of missile and electronic equipment, where the use of nitrogen as an inert gas plays an important part. In the growing electronics industry germanium and silicon crystals, used in powerful transistors, are generated in a protective nitrogen environment. Nitrogen is also used in the electronics industry for flushing

and sealing vacuum tubes, for filling tubes to prevent oxidation, for inert gas welding of external transistor parts and for environmental low temperature testing.

The Air Reduction Sales Co., a subsidiary of the Air Reduction Co., Inc., now operates

Cold nitrogen vapour testing of missile component at −300° F.

42 nitrogen plants in the United States. Other major producers include the Linde Co. Division of the Union Carbide Corporation and the National Cylinder Gas Co. Division of the Chemetron Corporation. Production of nitrogen gas in the United States in 1958 totalled 6.6 billion cubic feet.

AUSTRIA

Recovery of Nitric Acid Catalyst

Oesterreichische Stickstoffwerke A.G. of Linz have patented a method for the recovery of platinum and rhodium-platinum catalysts used in the manufacture of nitric acid. The new system is claimed to afford a recovery rate of 60-88%, and could make it feasible to operate under conditions which are at present uneconomic owing to the high catalyst losses incurred.

Platinum and rhodium, vapourised at between 800° and 950°C are recovered by a filter consisting of a 2½ inch layer of lime supported by a wire mesh sieve. After removal of the filter, the lime is dissolved and treated with nitric acid for recovery of the metals. One tonne of lime, costing about £4 will filter up to 6.5lbs. of platinum and rhodium and is effective for about a year. Platinum and rhodium are currently valued at £28 10s. and £45 a troy oz. respectively.

A recovery system developed in the United States involving the use of a glass fibre filter in the reactor outlet has not been universally adopted as it results in a higher pressure drop across the filter. Of the current world production of platinum of 800,000 troy ozs. about 60% is used in the manufacture of gauzes for nitric acid production.

EIRE

Postponement of Shannonbridge Project

The Government has considered the report of the committee set up to study the £7 million project for a nitrogen fertilizer plant at Shannonbridge in County Offaly and has decided, in view of the current decline in the price of imported material, that it would be inopportune to start construction work at once. The detailed planning of the factory will, however, be completed so that building can start without delay at any time.

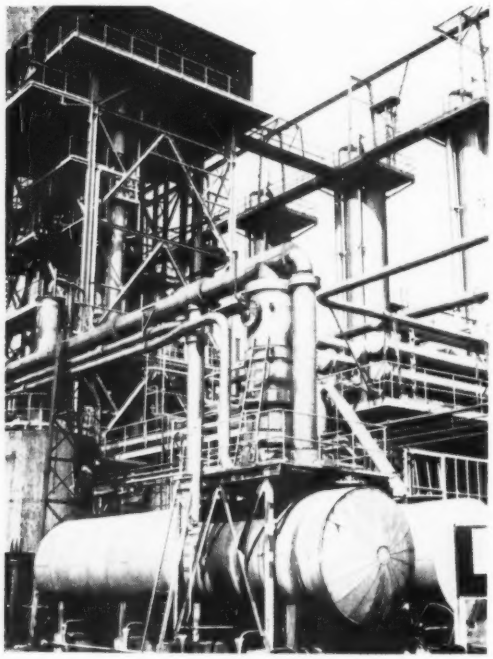
The Shannonbridge plant is to have an annual capacity of 100,000 tons of ammonium nitrate, 6,600 tons of nitric acid and 1,650 tons of ammonia for industrial use. Hydrogen for ammonia synthesis will be obtained by the gasification of milled peat from the Blackwater Bog. This does not appear to offer major technical difficulties and it is thought that production costs will be relatively low. Plans have also been drawn up to enable fuel oil to be used as an alternative source of hydrogen.

The advantage of establishing a domestic nitrogen industry using low cost indigenous raw materials have been recognised and, in this case, it would be in the power of the Government to ensure the continued availability of cheap fertilizers to the farmers. Unless it is thought that Eire's growing requirement of fertilizer nitrogen can be met by imports maintained at their present level, it is unlikely that the Shannonbridge project will remain for long in a state of suspended animation.

HOLLAND

MEKOG to use Natural Gas

N.V. Maatschappij tot Exploitatie Van Kooksovengassen (MEKOG) have awarded a contract to Chemical Construction (G.B.) Ltd., of London for a plant to reform natural gas for use in the manufacture of synthetic



Synthesis gas plant.

ammonia at their Ijmuiden works. The plant will reform approximately 125,000 cubic metres of gas a day. The gas, which will be supplied to Mekog under a long-term contract, is to be brought by a 50-mile pipeline from the oil and gas fields of Western Holland.

NORWAY

Temporary Suspension at Notodden

Ammonia production has been temporarily suspended at the Notodden works of Norsk Hydro Elektrisk Kvaelstofaktieselskab as a result of the very serious shortage of hydro-electric power in South Norway. The Notodden works, with an annual capacity of 10,000 tonnes N, is, however, the smallest of the three synthetic ammonia plants operated by Norsk Hydro. Those at Rjukan and Glomfjord have annual capacities of 195,000 and 65,000 tonnes N respectively. Repair work at Glomfjord has recently been completed and production will be a little higher than previously as the plant will be operated above its rated capacity.

Ammonia from all three plants is shipped to Norsk Hydro's works at Eidanger for use in the manufacture of nitrogen fertilizers, although at both Rjukan and Glomfjord a proportion is retained for use in the production of calcium nitrate. At the Eidanger works end products include calcium nitrate, ammonium nitrate, lime ammonium nitrate, sodium nitrate, compounds, urea and ammonium bicarbonate. The capacity of the urea plant at Eidanger is estimated at 75,000 tonnes.

It has been reported that Norsk Hydro may manufacture ammonia at Mo i Rana using waste gases from steel works, but such plans are as yet only at a preparatory stage. If they are realised ammonium sulphate may be manufactured. In 1958 the company produced 210,000 tonnes N at its three synthesis plants but had to supplement these supplies by imports of about 20,000 tonnes of liquid ammonia from West Germany.

POLAND

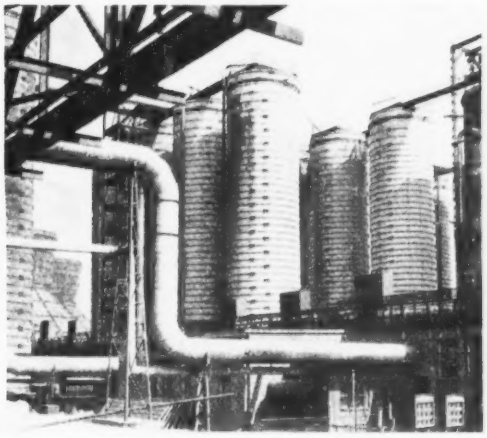
Rapid Expansion

Extensions at the new nitrogen fertilizer works at Heydebreck in Southern Poland will double the present capacity of approximately 40,000 tonnes N a year. The bulk of the ammonia produced at these works, commissioned in May 1958, is used in the manufacture of some 200,000 tonnes of lime ammonium nitrate annually, and output of this material will also be doubled. Production of ammonia at Heydebreck, one of the three largest combines of its type in Poland, is based on the use of coke-oven gas.

The two other large nitrogen plants in Southern Poland, at Tarnow and Kedzierzyn, are also to be expanded. At Tarnow, where water-gas is the source of hydrogen in a plant with an annual capacity of 75,000 tonnes N, natural gas will be used as the raw material for additional ammonia production, which by 1965 will total 245,000 tonnes N. The Kedzierzyn Chemical Combine, when com-

pleted, will be the largest nitrogen works in Poland. Much of the present capacity of 132,000 tonnes N is based on the use of water-gas, but coke-oven gas is to be used in additional plant now being installed. Further extensions, designed to raise the capacity of these works to 250,000 tonnes N per annum, will use natural gas as the source of hydrogen. Both ammonium sulphate and ammonium nitrate are manufactured at Kedzierzyn, and a 22,000 tonnes per annum urea plant is at present under construction.

Great emphasis is being placed on the reconstruction of Poland's nitrogen industry which suffered very heavy damage in World War II. Production, which rose from 73,000 tonnes N in 1949 to 154,000 tonnes N in 1955, has since risen to its present level of 260,000 tonnes N a year. Although it is unlikely to reach the official target of 360,000 tonnes N in 1960, it is expected to exceed the 300,000 tonnes level in that year. The bulk of Poland's nitrogen output is being used in an intensive effort to raise her agricultural production and it is planned to double the present rate of nitrogen fertilizer application — 15kg. per hectare of arable land—by 1965.



Poland. Nitric acid plant.

WEST GERMANY

Conversion to Natural Gas

The leading West German nitrogen producer, Badische Anilin und Soda Fabrik A.G. have signed a contract with the Wintershall - Mobil Oil - ITAG consortium to receive 100,000 cubic metres of natural gas a day from deposits at Frankenthal, a few miles from their Oppau works at Ludwigshafen-am-Rhein. B.A.S.F. will use the methane as a source of hydrogen for the manufacture of synthesis gas. This will represent the basis of only about 5% of the total ammonia capacity of the works but it is likely that economic advantages afforded by the use of natural gas will subsequently lead to its substitution for coal to a considerably greater extent.

At Oppau, ammonia is produced by the Haber-Bosch process and is used in the manufacture of ammonium sulphate, ammonium nitrate, lime ammonium nitrate, ammonium sulphate nitrate, calcium nitrate and urea. Substantial quantities of ammonia and nitric acid are also consumed in a wide range of technical applications within the Oppau works, and are sold for industrial use to other firms in West Germany.

COLOMBIA

Funds Obtained for Fertiliser Plant

Arrangements have been made to finance the completion of the nitrogen fertilizer works at Barrancabermeja where construction work, which started three years ago, has been at a standstill for several months owing to lack of funds. An internal loan of 30 million pesos has been obtained from Colombian banks at favourable terms and this will used to cover initial operating costs and the erection of buildings to house the installations. Futher loans totalling about U.S. $4 million have been offered by the International Bank of Reconstruction and Development, the Export-Import Bank and foreign interests to cover the cost of equipment.

The plant, the first of its type in Colombia, was to have been completed in 1959 but is unlikely to come on stream before 1961. Fauser-Montecatini processes are to be employed in the manufacture of ammonia from natural gas at a rate of 17,000 tons a year, and in the production of nitric acid, ammonium nitrate and urea. Ammonium nitrate and urea capacities are to be 32,000 tons and 10,000 tons a year respectively, representing double the current nitrogen fertilizer use of the country.

MEXICO

Three Plants for Petroleos Mexicanos

An important feature of the rapid development of the Mexican nitrogen industry is the planned construction by Petroleos Mexicanos (Pemex) of three synthetic ammonia plants. Each of these plants will have a capacity of 200 short tons a day (66,000 short tons per annum) using hydrogen obtained from natural gas. Although designed by United States plant construction companies, all three plants will be erected by Petroleos Mexicanos.

One of the ammonia plants will be adjacent to the oil refinery at Salamanca. The Lummus Corporation, which has been awarded a $21 million contract for the expansion of this refinery, will also be responsible for the design of the ammonia plant. The second ammonia plant is being designed by the Fluor Corporation Ltd. and, employing the Claude process, will be built at Minatitlan in the centre of the sulphur producing area on the Isthmus of Tehuantepec. The third plant will be designed by the Chemical Construction Corporation of New York and will be built on the Pacific coast, although the actual location has not yet been decided. It is estimated that four-fifths of the ammonia produced at these plants will be used in the manufacture of fertilizers, the balance being used in the manufacture of synthetic fibres and explosives. It is not yet decided which fertilizers will be produced in the three plants but it is believed that the bulk will be in the form of ammonium nitrate and urea. Production of fertilizer nitrogen in Mexico, currently at an annual level of 13,000 tonnes N, meets less than 10% of demand. The anticipated rise in consumption is such that even when the three large plants planned by Pemex are in operation, there should still be a substantial import requirement.

PERU

Nitroglycerine

Built in desert country some 24 miles south of Lima, a nitroglycerine plant was commissioned on 8th August, 1959 by Explosivos S.A. The new plant has a capacity of 110 gallons an hour and can supply about 75% of Peru's requirements of this explosive. Imports of nitroglycerine, mainly supplied from the United States, have been at an annual level of 1 million gallons at a cost of some U.S. $2.5 million.

It is understood that nitric acid used in the new plant is supplied by Fertilizantes Sinteticos S.A. from their works recently brought into operation at Callao, a few miles north of Lima. The bulk of the nitric acid produced at Callao is for captive use in the manufacture of 25,000 tons of fertilizer grade and 5,000 tons of technical grade ammonium nitrate a year.

JAPAN

Toyo Koatsu to Produce Urylon

A new synthetic fibre, U-RYLON, is now being made in a pilot plant by the Japanese firm of Toyo Koatsu Industries Ltd. and production will be started on a commercial scale before the end of 1959 in a plant now under construction at Sunagawa on the island of Hokkaido. Output will initially be at a rate of 1 ton a day, but during 1960 it will be raised gradually from this level to between 15 and 20 tons a day. U-RYLON, a polycondensation product of monamethylene diamine and urea, is considered to be a potential competitor with nylon.

A number of synthetic resins are at present manufactured by Toyo Koatsu Industries Ltd. The urea resins include U-LITE, used in moulding powders, U-LOID, an adhesive, U-RAMIN P, used for moisture-proofing paper, U-RAMIN T, used in the treatment of textiles and mixed fibres, and U-RIX, an air-drying lacquer. U-VAN is an amino-synthetic resin for coating materials for metal goods such as motor cars, refrigerators and bicycles.

Urea production in Japan is at a current level of 380,000 tonnes a year, of which some 40,000 tonnes are used in the manufacture of synthetic resins and fibres. If the present rate of expansion is maintained, this quantity should be doubled by 1975.

Statistical Appendix

United States

PRODUCTION

Short Tons

		Anhydrous Ammonia Synthetic	Ammonium Nitrate (100% NH_4NO_3) Total	Ammonium Nitrate (100% NH_4NO_3) Fertilizer	Ammonium Sulphate Synthetic	Ammonium Sulphate By-product	Nitric Acid (100% HNO_3)	Nitrogen Solutions (100% N)*
1957	**TOTAL**	**3,734,213**	**2,586,007**	**2,338,576**	**1,039,822**	**908,903**	**2,843,488**	**563,423**
1958	**TOTAL**	**3,831,420**	**2,524,057**	**2,272,905**	**1,097,750**	**640,852**	**2,601,915**	**631,903**
	July	294,664	176,748	162,311	85,776	48,019	191,792	30,283
	August	280,581	184,742	166,244	84,231	50,114	196,916	40,161
	September	304,753	208,760	186,150	92,583	51,526	223,748	56,088
	October	325,987	233,259	208,362	84,475	58,455	254,529	49,256
	November	333,860	237,067	214,407	96,327	61,564	258,135	54,078
	December	324,626	228,343	208,059	89,084	64,770	244,816	66,553
1959	January	333,805	227,887	207,464	88,531	63,604	240,780	52,119
	February	326,454	216,428	193,386	87,075	63,817	240,969	56,768
	March	384,128	249,724	222,768	94,940	73,774	267,215	87,249
	April	400,156	243,704	215,618	97,201	73,020	268,141	109,235
	May	413,134	244,336	219,238	88,795	71,568	261,689	95,420
	June	386,755	217,172	194,878	81,811	69,955	233,005	52,757
	July	366,509	216,296	194,531	72,926	24,764	233,412	40,486
	August	342,634	230,166	210,840	92,162	14,559	241,848	54,487

* Including combinations with urea.

W. Germany

EXPORTS JANUARY - JUNE 1959

Tonnes N

Lime Ammonium Nitrate and Ammonium Sulphate Nitrate

Bulgaria	44,250
Denmark	9,396
Finland	11,100
Greece	10,935
Eire	4,201
Iceland	6,046
Yugoslavia	66,777
Luxemburg	623
Netherlands	16,674
Portugal	6,502
Spain	11,200
Turkey	4,358
Ethiopia	252
Kenya and Uganda	2,165
Rhodesia and Nyasaland	6,610
Union of South Africa	4,374
U.S.A.	16,023
Costa Rica	1,487
Mexico	12,084
Puerto Rico	2,000
Federation of W. Indies	364
Argentine	1,276
Brazil	8,820
Colombia	330
China	21,141
India	70,957
South Korea	503
Lebanon	1,872
Syria	4,618
Australia	3,564
New Zealand	724
Total	**351,226**

Sodium Nitrate

Rhodesia and Nyasaland	521
U.S.A.	1,000
Brazil	1,042
New Zealand	619
Total	**3,182**

Ammonium Sulphate and Calcium Cyanamide

Saar	480
Belgium	21,383
Denmark	9,899
Greece	6,295
Great Britain	31,253
Eire	11,329
Luxemburg	292
Austria	1,361
Portugal	3,335
Sweden	4,149
Spain	104,707
Turkey	18,457
Canary Islands	21,803
Kenya and Uganda	323
Libya	524
Morocco	734
Rhodesia and Nyasaland	5,969
Sudan	6,303
Union of South Africa	16,985
Tanganyika	812
Costa Rica	846
Cuba	2,358
Mexico	9,683
Puerto Rico	1,814
El Salvador	13,864
Federation of W. Indies	6,305
Argentine	4,501
Brazil	19,144
Colombia	992
Peru	12,761
Venezuela	7,546
Burma	1,794
China	16,744
Indonesia	3,091
Iraq	663
Jordan	545
South Korea	50,103
Lebanon	2,657
Malaya	4,648
Philippines	2,959
Singapore	367
Syria	970
Thailand	1,351
New Zealand	810
Total	**435,909**

Ammonium Nitrate

Greece	350
Portugal	302
Morocco	1,151
Peru	360
Total	**2,163**

Calcium Nitrate and Calcium Magnesium Nitrate

Belgium	378
Denmark	28,230
Yugoslavia	8,814
Austria	960
Portugal	6,042
Sweden	4,278
Spain	36,978
U.S.A.	2,976
Brazil	1,008
Lebanon	684
Syria	3,564
Total	**93,912**

Other Nitrogenous Fertilizers (including Urea)

Portugal	363
Morocco	250
Zanzibar	1,051
Union of South Africa	589
U.S.A.	1,882
Costa Rica	234
Mexico	962
Brazil	1,727
Ecuador	805
Colombia	2,498
Peru	3,185
Malaya	688
Singapore	565
Thailand	130
Australia	241
Total	**15,170**

Belgium

PRODUCTION

Tonnes

		Synthetic Ammonia		By-product Ammonium Sulphate	Fixed Nitrogen for technical use	Compound Fertilizers	
		Total N content	Fertilizer N content	N content	tons product	tons product	N content
1957	1st quarter	52,112	42,797	4,368	2,612	52,089	4,064
	2nd quarter	59,877	43,445	4,067	1,998	31,282	2,873
	3rd quarter	58,429	52,404	4,431	1,892	35,491	2,504
	4th quarter	63,279	57,930	4,136	1,533	38,125	1,775
1957	**TOTAL**	**233,697**	**196,576**	**17,002**	**8,035**	**156,987**	**11,216**
1958	1st quarter	64,691	58,723	4,255	1,401	66,461	6,768
	2nd quarter	68,079	63,747	4,871	1,734	56,199	6,236
	3rd quarter	69,684	50,465	4,572	1,545	46,726	4,171
	4th quarter	72,469	66,189	4,543	1,764	72,292	5,521
1958	**TOTAL**	**274,923**	**239,124**	**18,241**	**6,444**	**241,678**	**22,696**
1959	1st quarter	75,593	68,812	3,688	1,644	70,866	5,305
	2nd quarter	78,241	71,400	4,104	1,367	48,832	5,415

EXPORTS 1958/1959

Tonnes

Ammonium Sulphate

Great Britain	50,555
France	198
Eire	16,793
Portugal	14,970
Spain	149,656
Greece	15,028
Belgium Congo	512
Kenya and Uganda	612
Tanganyika	192
Jamaica	5,019
Dominican Republic	17,658
British Guiana	7,132
Brazil	767
Argentine	2,688
Mexico	5,668
Ceylon	52,557
Malaya	19,177
Singapore	200
China	301,598
New Zealand	61
Total	**661,041**

Ammonium Nitrate

Eire	513
Portugal	12,000
Yugoslavia	30,324
Greece	4,000
Egypt	11,500
Belgium Congo	87
China	146,602
New Zealand	166
Total	**205,192**

Calcium Cyanamide

Netherlands	2,379
Great Britain	26
France	1,730
Portugal	1,486
Morocco	105
Belgium Congo	350
Total	**6,076**

Other Nitrogenous Fertilizers

Netherlands	9,586
West Germany	14
Great Britain	384
Total	**9,984**

Ammonium Phosphate

Netherlands	4,408
Great Britain	8,888
Eire	533
Austria	15
Greece	1,581
Belgium Congo	45
Colombia	4,346
Mexico	300
El Salvador	100
British Guiana	1,016
Costa Rica	150
Uruguay	312
Argentine	50
Equador	50
Iran	2,000
Burma	1,000
Malaya	325
Mauritis	10
Total	**25,129**

Urea

Netherlands	50

Netherlands

EXPORTS JANUARY - AUGUST 1959

Tonnes

Ammonium Sulphate

Belgium-Luxembourg	99
Great Britain	6,746
Eire	20,932
Sweden	2,031
Spain	65,000
Greece	7,871
Turkey	4,391
Canary Islands	4,750
Union of South Africa	1,777
El Salvador	2,377
Cuba	5,080
Jamaica	3,217
Surinam	1,258
Peru	1,500
Brazil	3,320
Argentine	4,113
Indonesia	3,551
Ceylon	18,830
Thailand	2,550
China	21,209
New Zealand	850
Others	1,554
Total	**183,006**

Ammonium Nitrate

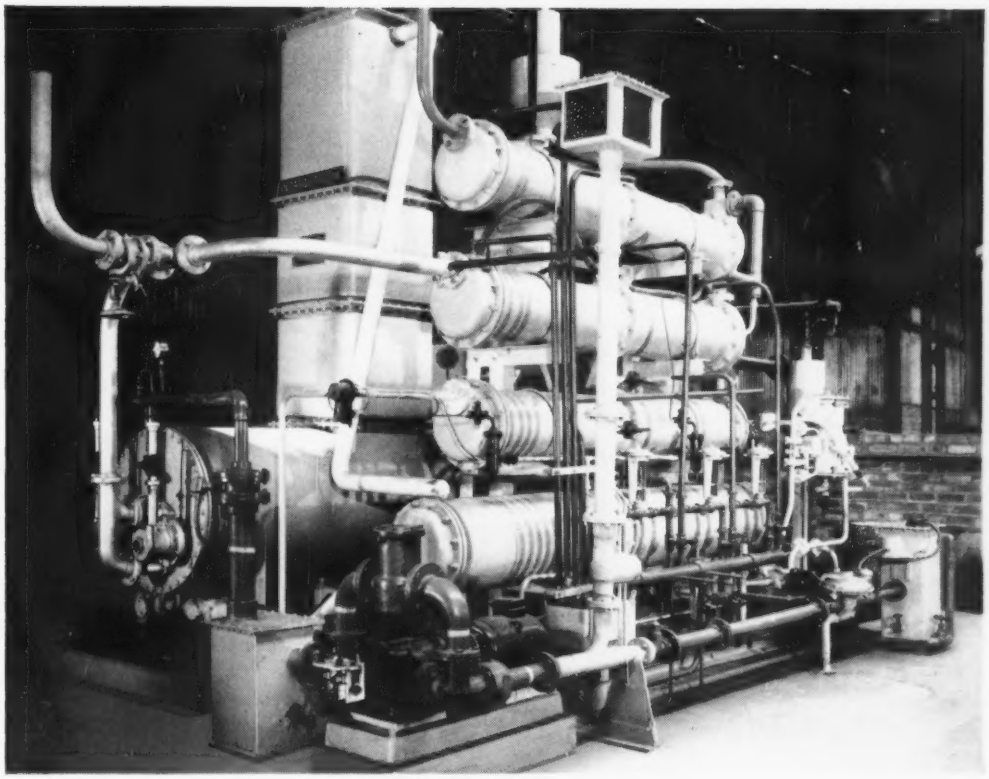
Belgium-Luxembourg	5,902
Portugal	3,453
Yugoslavia	70,109
Greece	1,000
Bulgaria	28,200
Union of South Africa	2,536
Rhodesia	1,007
U.S.A.	102,675
Brazil	3,188
Israel	5,912
China	30,907
Australia	841
New Zealand	1,035
Others	78,983
Total	**335,748**

Calcium Nitrate

Belgium-Luxembourg	3,945
Sweden	22,260
Portugal	1,976
Yugoslavia	19,342
U.S.A.	6,292
Others	5
Total	**53,820**

Ammonium Phosphate

Belgium-Luxembourg	80
Great Britain	921
Indonesia	203
Others	590
Total	**1,794**



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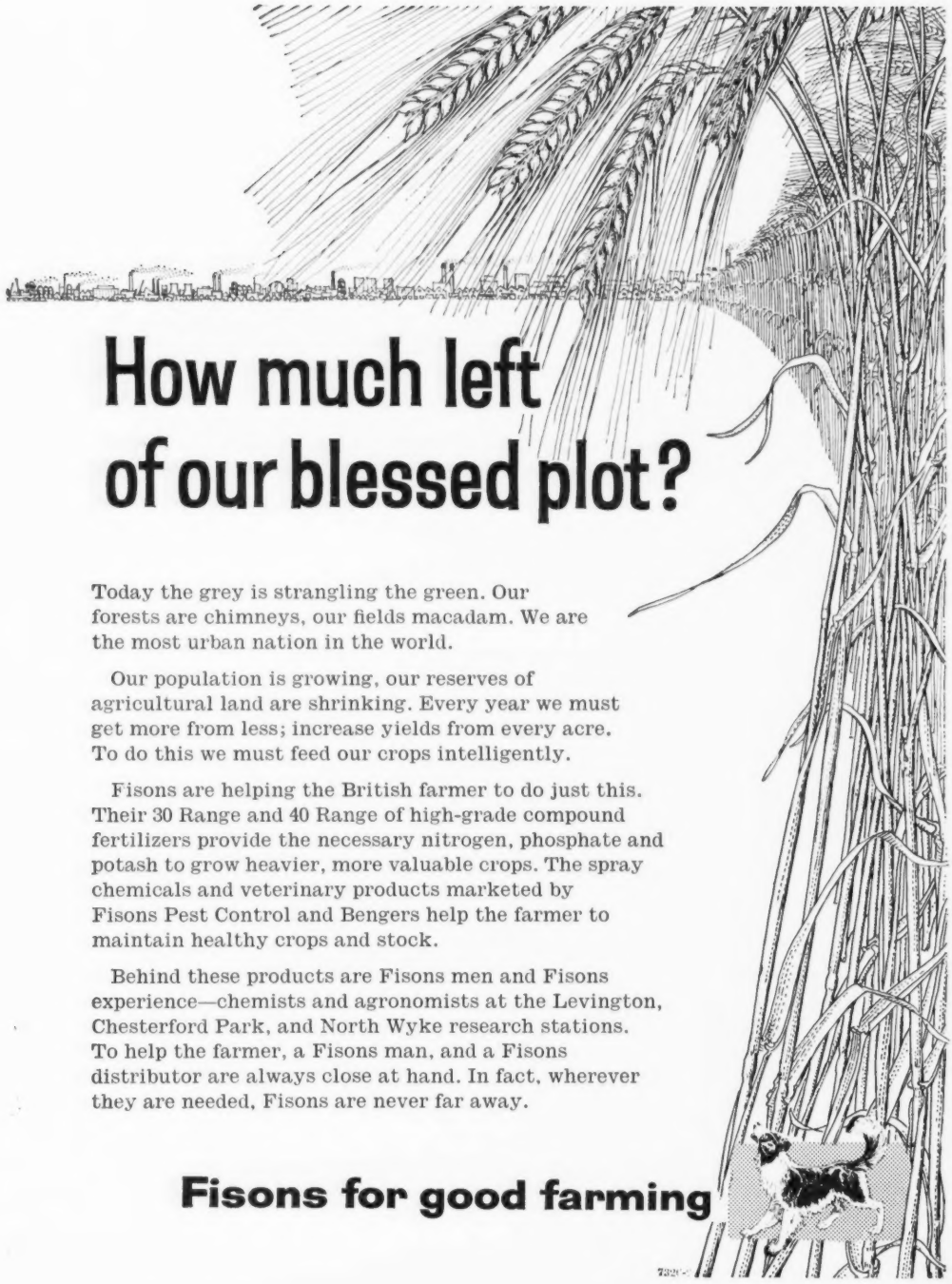

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